UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

DEC 22 2006 In response refer to:
2006/05501

E. Scott Clark
Chief, Planning Division
U.S. Army Engineer District, Sacramento
Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Mr. Clark:

This document transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure 1) based on our review of the proposed Sacramento River Bank Protection Project (SRBPP) 14 Critical Levee Erosion Repairs, and their effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), and their designated critical habitat in accordance with section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). This biological opinion also includes a section 7(a)(2) analysis of project related effects on the threatened Southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*).

The proposed levee repairs are part of the ongoing SRBPP, and are pursuant to Governor Schwarzenegger's February 24, 2006, emergency proclamation for California's levee system. The Governor's proclamation ordered the emergency repair of levees to prevent the imminent loss of human property and life. From July 2006, through November 2006, the Corps and the California Department of Water Resources (CDWR) constructed 33 critical levee erosion repair projects. Annual levee inspections conducted during the construction of these 33 projects revealed 24 additional critical levee erosion sites that need immediate repairs to prevent the imminent loss of human property and life. The Corps will construct 14 of the repairs and the California Department of Water Resources (CDWR) will repair the other 10. This biological opinion addresses the 14 Corps-led levee repairs. A separate biological opinion will be prepared for the CDWR-led sites.

Your request for formal consultation was received on October 31, 2006. Because of the imminent threat to human life and property, the Corps proposed an Action Plan and Alternative Consultation Procedure to expedite the design, environmental review, and construction of these sites while avoiding an irreversible or irretrievable commitment of resources, pursuant to section 7(d) of the ESA. The Corps' proposed Action Plan and Alternative Consultation Procedures were developed to provide NMFS with the information necessary to complete the ESA section 7 consultation, and Magnuson-Stevens Conservation and Management Act (MSA) Essential Fish Habitat (EFH) consultation, concurrent with the levee repair actions. Therefore, NMFS initiated formal consultation on November 1, 2006.

This biological opinion is based on information provided in the December 2006, environmental assessment (EA) and the biological assessment (BA) for Corps-led sites. The biological opinion also is based on design drawings for all projects, information provided at Collaborative Flood Maintenance Program meetings, and site visits and discussions held with representatives of NMFS, USFWS, the California Department of Fish and Game (CDFG), the Corps, and Ayres and Associates. A complete administrative record of this consultation is on file at the NMFS Sacramento Field Office.

Based on the best available scientific and commercial information, the biological opinion concludes that these projects are not likely to jeopardize the above species or adversely modify designated critical habitat. NMFS has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to minimize incidental take associated with project actions. The listing of the Southern DPS of North American green sturgeon became effective on July 7, 2006, and some or all of the ESA section 9(a)(1) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). Because there are no section 9(a)(1) prohibitions at this time, the incidental take statement, as it pertains to the Southern DPS of North American green sturgeon does not become effective until the issuance of a final 4(d) regulation, as appropriate.

Also enclosed are draft EFH Conservation Recommendations for Pacific salmon as required by the MSA as amended (16 U.S.C. 1801 *et seq.;* Enclosure 2). This document concludes that the SRBPP 14 Critical Emergency Levee Repairs will adversely affect the EFH of Pacific Salmon in the action area and adopts certain of the terms and conditions of the incidental take statement and the ESA Conservation Recommendations of the biological opinion as the EFH Conservation Recommendations.

Section 305(b)4(B) of the MSA requires the Corps to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR ' 600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

If you have any questions regarding this correspondence please contact Mr. Howard Brown in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, California 95814. Mr. Brown may be reached by telephone at (916) 930-3608 or by Fax at (916) 930-3629.

Sincerely,

Russell M Strach

for Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc: Copy to file: 151422SWR2006SA00115:HLB
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Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY:	United States Army Corps of Engineers Sacramento District
ACTIVITY:	Sacramento River Bank Protection Project, 14 Critical Levee Erosion Repairs
CONSULTATION CONDUCTED BY:	NOAA's National Marine Fisheries Service, Southwest Region
FILE NUMBER:	151422SWR2005SA00115
DATE ISSUED:	December 22, 2006

I. CONSULTATION HISTORY

On February 24, 2006, Governor Arnold Schwarzenegger issued an emergency proclamation for California's levee system. The proclamation focused on the imminent threat of 24 critical levee erosion sites located in Colusa, Sacramento, Solano, Sutter, Yolo, and Yuba counties.

On March 6, 2006, Governor Arnold Schwarzenegger sent a request to the Corps seeking assistance with the critical erosion site repair.

On March 31, 2006, the Corps committed to the repair of 10 of the original 24 critical sites, contingent on the Corps receiving approval to accept funding from CDWR. The Corps also indicated it plans to repair an additional four sites in the Pocket area of Sacramento not listed on the critical list, and April 20, 2006, the Corps added five sites to list of 24 critical erosion sites.

On June 21, 2006, NMFS issued a biological opinion for the construction of 20 critical levee repair projects.

On September 15, 2006, the Corps requested an amendment to the June 21, 2006, biological opinion to construct 4 additional critical sites.

On October 18, 2006, NMFS issued an amended biological opinion in response to the Corp's September 15, request.

On October 31, 2006, The Corps requested section 7 consultation for 14 critical levee erosion repair projects. This request included an Action Plan and Alternative Consultation Procedure to expedite the design, environmental review, and construction of these sites while avoiding an irreversible or irretrievable commitment of resources, pursuant to section 7(d) of the ESA.

On November 1, 2006, NMFS initiated formal section 7 consultation for 14 critical levee erosion repair projects.

On November 2, and 3, 2006, the Corps led NMFS, USFWS, and CDFG on site visits to the 14 proposed project area and provided all available project information, including preliminary project cross sections. NMFS, USFWS, and CDFG provided preliminary recommendations for design considerations and integrated conservation measures to minimize impacts to protected natural resources.

On November 9, 2006, the Corps held a technical team meeting to discuss issues from field reviews.

On November 16, 2006, the Corps held a technical team meeting to provide draft final project designs, preliminary SAM results, and to resolve all draft final project design issues with NMFS, USFWS, and CDFG.

On December 1, the Corps provided NMFS with the final draft environmental assessment (EA) for Levee Repair of 14 Winter 2006 Critical Sites, Sacramento River Bank Protection Project (Corps 2006). The EA included a biological assessment (BA) for Federally listed anadromous fish and their designated critical habitat, and an assessment of the project effects on EFH. The EA also included SAM data and results.

On December 5 and 6, 2006, Corp led NMFS on site visits to the 14 repair sites to discuss final designs Phase 1 designs and construction activities for Phase 1 and 2.

On December 19, 2006, NMFS provided the Corps with a review draft biological opinion. The Corps provided comments on December 20, 2006.

This biological opinion is based on information provided in the BAs; discussions held with the Corps, USFWS, CDFG, and SAFCA; field reviews of the erosion sites, SAM analyses; and engineering designs. A complete administrative record of this consultation is on file at the NMFS Sacramento Area Office.

II. DESCRIPTION OF THE PROPOSED ACTION

As a result of imminent threat of catastrophic levee failure, Governor Arnold Schwarzenegger declared a State of emergency for the California Levee system and ordered the immediate repair of critical levee erosion sites in the SRFCP, in Colusa, Sacramento, Solano, Sutter, Yolo, and Yuba counties to prevent the imminent loss of human life and property. The SRFCP consists of approximately 980 miles of levees, plus overflow weirs, pumping plants, and bypass channels that protect urban and agricultural lands in the Sacramento Valley and the Sacramento-San Joaquin River Delta (Delta). The projects will be constructed under the authority of the SRBPP.

The SRBPP is a continuing construction project, authorized by the Flood Control Act of 1960, to provide protection for the existing levees and flood control facilities of the SRFCP.

The U.S. Army Corps of Engineers (Corps) will take all necessary actions to stabilize 14 critical levee erosion sites along the Sacramento River and Steamboat Slough. The erosion sites are located along both sides of the river and slough, and are designated by distance in miles from the mouth, and either the right (R) or the left (L) bank. The convention for right and left bank designation is "as facing downstream;" therefore RM 16.9L is located 16.9 miles from the mouth, on the left bank as one faces downstream. Eleven of the 14 sites are along the Sacramento River at RM 16.9L, 33.0R, 33.3R, 43.7R, 44.7R, 47.0L, 47.9R, 48.2R, 62.5R, 68.9L, and 78.0L. Three critically eroding sites are along Steamboat Slough at RM 19.0R, 19.4R, and 22.7R. The 14 sites are located in Yolo, Sacramento, Sutter, and Solano counties.

Construction will occur in two phases. Phase 1 would place rock revetment at the sites during winter months of 2006 and 2007, to reduce the potential for the imminent failure of the levee system. Phase 2 will occur as winter water levels recede during the summer and fall months of 2007, and will place additional rock revetment and integrate self-mitigating design features that minimize project-related impacts to Federally listed species. Phase 2 will be accomplished by incorporating rock benches, that serve as buffers against extreme toe scour and shear stress while providing space for planting riparian vegetation and creating a platform to support aquatic habitat features.

All sites were selected based on a comprehensive erosion site evaluation prepared by Ayres and Associates (2006) for the Corps. The evaluation was made based on field surveys and quantitative ranking of characteristics, such as bank slope, bench width, length and location of erosion, radius of curvature, bank stability, dynamic geomorphology, vegetation cover, tree hazards, soil type, water velocity, wave action, economic factors, human use, seepage potential, and tidal fluctuation. Although the engineering and environmental solutions for each of these sites will differ somewhat, the types of erosion sites, the locations of the sites, the environmental resources of the sites, and the types of repair and restoration methods will be similar.

A. Project Description

The proposed action is to place rock and wood revetments along the waterside slope of each erosion site. The proposed levee repair work is designed to halt erosion, minimize the loss of riparian vegetation and nearshore aquatic habitat resulting from construction activities, prevent the eventual loss of nearshore aquatic habitat and riparian habitat that probably would occur if the project were not constructed, and provide compensation, if needed, for unavoidable impacts to existing riparian habitat and nearshore aquatic habitat. Project locations are shown on Figure 1, and Appendix A, Figure 1. Project details are shown in Table 1. Conceptual project cross-section and aerial photographs of project footprints are shown in Appendix A, Figures 2 through 28. The cross sections are preliminary and are subject to modification as Phase 2 designs are developed.

The bank protection measures generally would consist of: (1) reinforcement of the bank toe with rock riprap; (2) placement of a mixture of soil and rock on top of the toe riprap to create a bench that slopes at a 10:1 ratio to the water; (3) placement of rock and soil along the upper slope, and covering the rock with soil; (4); anchoring IWM and brush bundles along the waterside edge of the bench, on the bench surface, and on the bank slope to enhance fish habit; and (5) planting the bench and the upper slope with vegetation to increase bank protection and establish riparian habitat.

The bank protection projects will repair bank and levee erosion and restore and enhance the riparian and shaded riverine aquatic (SRA) habitat. Generally, this will be accomplished by incorporating rock benches, that serve as buffers against extreme toe scour and shear stress while providing space for planting riparian vegetation and creating a platform to support aquatic habitat features. This design, which has been employed along the lower Sacramento and American Rivers, and the recently-constructed critical levee erosion repairs, will protect existing SRA habitat and create elements of natural SRA habitat that otherwise would be lost as a result of project construction activities and continued erosion.

The bench design functions to repair existing scour, to provide a buffer against extreme toe scour, to develop a surface and soil for plantings, and to provide shallow-water habitat for juvenile fish rearing and refugia. Two types of benches will be constructed. Emergent wetland benches will be constructed below the average summer water surface elevation to mimic existing shallow water habitat in the Delta and provide a surface for growing emergent wetland plants such as tules. Riparian floodplain benches will be constructed that slope toward the water between the average spring water surface elevation and the average summer water surface elevation. Both bench types will be constructed downstream from RM 30, and riparian floodplain benches will be constructed upstream from Sacramento RM 30. Riparian benches upstream from Sacramento RM 30 will include IWM, a variable shoreline, and riparian vegetation that will mimic the ecosystem functions of natural floodplain habitat, except that it will not contain natural erodable substrate.

The roughness factor associated with grown-out plantings will reduce both flow velocities and shear stress against the bank. Existing on-site IWM will be retained to the fullest extent possible. The bench will provide a platform to anchor added IWM structures for fish habitat, and will vary in height to provide seasonally flooded areas and velocity refugia at a variety of flow conditions.

Emergent wetland benches will remain under water under most flow and tidal conditions. Hydrologic assessment of the Sacramento River indicates that flows sufficient to inundate the riparian benches are likely to occur in most years from January through March. During extremely high flow years, riparian benches may be inundated as early as November to as late as July. Riparian benches typically will not be inundated during the summer and fall months, and will not be inundated under any flow scenario from the beginning of July through mid-November.

Living and dead IWM would be placed along the sites to create diverse fish habitat features and refugia. IWM will be placed along the sites to ensure that there is functioning IWM along 80 percent of the length of the shoreline to provide bank protection and aquatic habitat for sites on the Sacramento River upstream from RM 30. IWM above 40 percent at each site would be credited to: (1) sites below RM 30; (2) any compensation deficits remaining on-site at the proposed projects, (3) any compensation deficits for SRBPP projects constructed since 2001, and (4) to increase the value of any off-site compensation constructed in the future. A comprehensive analysis of cumulative effects to the baseline of the species affected would be completed in fall 2007 to determine the need for additional compensation or any offsets that are allowed for future SRBPP projects.

Individual pieces of IWM will be 23 to 35 feet long, maintain crown structure that is at least 6 to 8 feet wide, retain limbs and root wads, to the extent feasible, for maximum habitat value. IWM would be placed on the surface of the bench and anchored by covering the IWM with the placed rock revetment or cables. All branches, limbs and twigs would be retained to the extent practicable to maintain the size, volume, and complexity. Cabled IWM may be sheered to allow a flat alignment of each finished IWM piece against the finished riprap surface. The Corps and CDWR environmental representatives in coordination with NMFS and USFWS would determine the most beneficial placement of IWM during construction. IWM generally will be installed at all sites upstream from RM 30. From RM 30 downstream, and at sites in Steamboat Slough, emergent vegetation will be planted into bench features instead of installing IWM in order to minimize the likelihood of increasing structural predator cover to protect Federally listed threatened Delta smelt (*Hypomesus transpacificus*).

Standing and fallen trees at the project sites would be protected in place to the maximum extent possible, and all disturbed areas would be protected with erosion control measures such as hydro seeding and plug plantings. Where necessary, clearing of smaller vegetation from the levee slope would be accomplished using small equipment and/or hand tools. Some pruning of trees may be required during the construction phase. If IWM is removed to install bank protection features, it will be anchored back in place and incorporated into supplemental IWM installation. Exotic species may be removed, and the area replanted with native species appropriate for the location and elevation on an acre-for-acre basis, without the need for any additional mitigation for such removal.

Riparian trees and shrubs would be planted along the project sites at elevations extending from near the summer water level, towards the top of the bank. Vegetation generally will be planted on two-to five-foot centers, in three to four zones. Planting zones may include emergent marsh, emergent bench, transition slope, riparian bench, and levee slope. Planting plans vary by sight and location of project features in relation to the size and slope of the levee. Both restricted and unrestricted planting plans will be developed for Phase 2 implementation. Restricted plans red willow (*Salix* lasiolepis), and narrowleaf willow (*Salix* exigua). Large tree species such as oak, sycamore, and cottonwood are not included in restricted plans because of long-term levee stability concerns. Unrestricted plans include a diverse assemblage of species including box elder (*Acer negundo*), white alder (*Alnus rhombifolia*), Oregon ash (*Fraxinus latifolia*), Western sycamore (*Platanus* racemosa), Fremont cottonwood (*Populus* fremontii), Valley oak (*Quercus* lobata), Gooding's willow (*Salix gooddingii*), red willow, arroyo willow (*Salix lasiolepis*), California wild rose (*Rosa californica*), and narrowleaf willow. Generally, large container plants and live pole cuttings will be collected from areas adjacent to the project site or from riparian habitats within the Sacramento Valley at sites within a 50-mile radius of the project site.

During Phase 1 all construction would be conducted on the waterside of the riverbank from a barge or on top of the fill material. Phase 2 waterside construction would occur at Sacramento RMs 16.9L, 33.0R, 33.3R, 43.7R, and Steamboat Slough RMs 19.0R, 19.4R, and 22.7R. Phase 2 landside construction would occur at Sacramento RMs 47.0L, 62.5R, 68.9L, 78.0L, and possibly 47.9R, and 48.2R. The contractors would use the top of the levee and adjacent grassy areas for staging of vehicles and plant materials only if necessary. Access points will be limited at Phase 2 landside construction sites to minimize shoreline and riparian disturbance. Use of construction equipment on the berm or landside may occur to place rock or soil in a manner that minimizes the loss of riparian vegetation.

During Phase 1, the contractor would place rock revetment at the toe of the levee slope. During Phase 2, the contractor would begin placing a combination of rock and sandy soil to construct a bench. The proportion of rock to soil will be approximately 70:30. Once the bench is complete, soil will be placed over the bench area as a planting medium, IWM will be installed, and riparian vegetation will be planted. The contractor may choose to use excavators, loaders, and other construction equipment on the construction area once the rock revetment is above the water surface.

Incorporation of environmental features that restore riparian and SRA habitat is a key aspect of the proposed action. As a result, off-site compensation and/or mitigation for impacts on these types of habitats from project construction activities will be implemented only to the extent that the project design does not fully offset these impacts.

Overall, the project would reinforce approximately 9,817 linear feet (lf) of shoreline, covering approximately 21.7 acres, with 8.4 acres being below the MSW. The area above the MSW will be covered with soil and planted with riparian vegetation. Approximately 7,705 lf of IWM will be placed at winter/spring water elevations. Exact amounts are subject to minor change. If project lengths increase, the application of conservation measures will be extended accordingly.

B. Construction Schedule and Periods

Construction will occur in 2 phases. Phase 1 is expected to occur between November 13, 2006 and June 1, 2007 and will continue until all sites are stabilized. Phase 2 will occur between June 1, 2007 and November 30, 2007. Construction on dry land may occur in months prior to or following this period. Construction primarily is scheduled to occur during daylight hours. Construction activities may be temporarily suspended due to high flows or rain.

Figure 1. Map of the action area and 14 critical levee erosion repair sites.

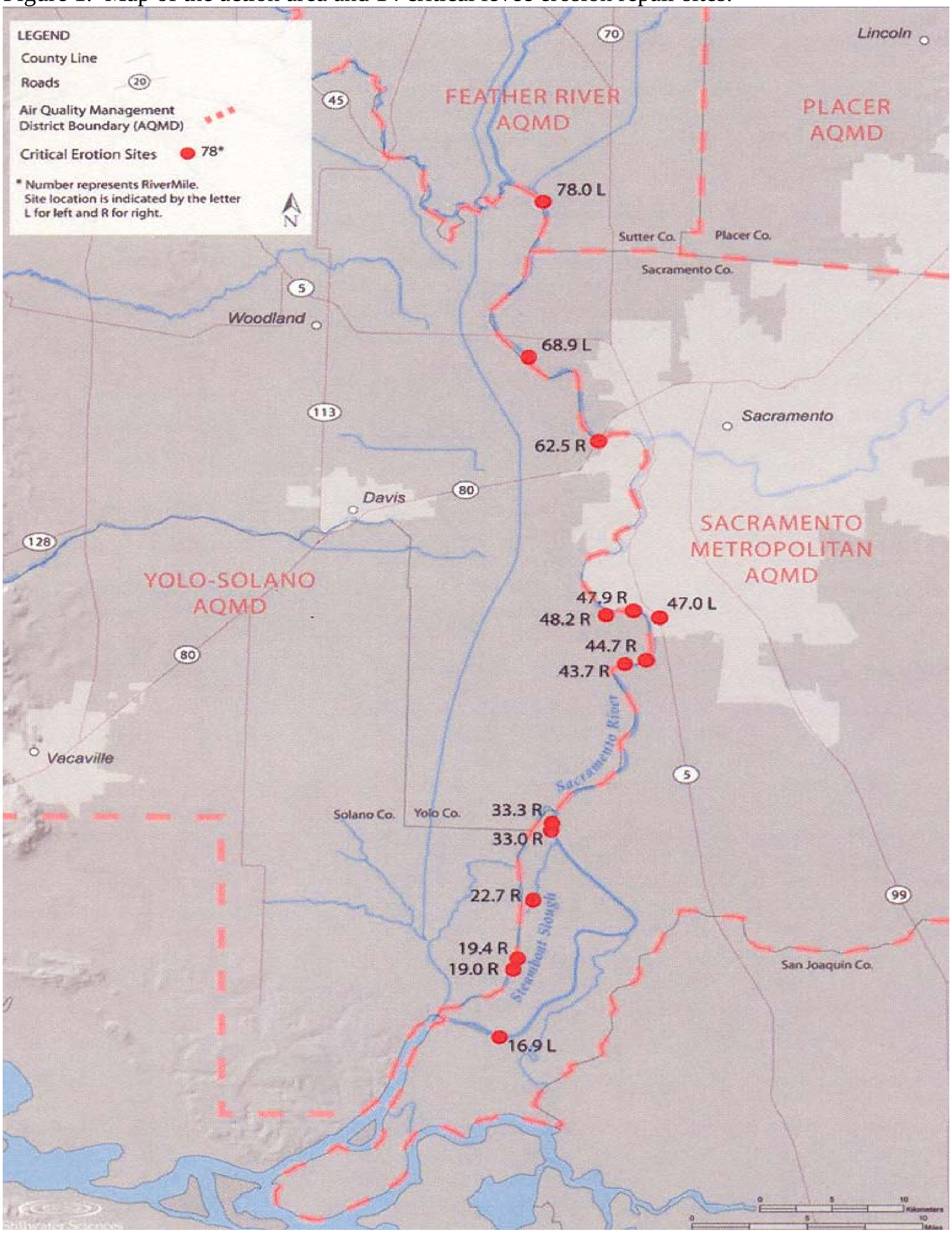

Table 1. Project locations and engineered design features for Corps critical levee emergency repair sites.

Waterbody	River Mile	Length (feet)	Total Project footprint (acres)	Volume of riprap placed (yd3)	Volume of riprap/soil mixture placed (yd3)	Area below mean summer water elevation (acres)	Area Above mean summer water elevation (acres)	Existing IWM (feet)	IWM to be placed above mean summer water elevation (lf)	Emergent Wetland Bench	Riparian Floodplain Bench	Planting Plan
Sacramento River	16.9 L	210	0.4	2,722	1,750	0.3	0.2	30	NA	Yes	Yes	Restricted
Sacramento River	33.0 R	326	0.9	7,848	2,656	0.5	0.4	25	293		Yes	Restricted
Sacramento River	33.3 R	235	0.7	5,361	2,559	0.3	0.4	15	212		Yes	Restricted
Sacramento River	43.7 R	1,090	2.5	14,533	14,533	1.0	1.5	65	981	Yes	Yes	Restricted
Sacramento River	44.7 R	1,585	3.6	19,372	17,846	1.0	2.6	243	1,427		Yes	Restricted
Sacramento River	47.0 L	1,156	2.0	8,734	5,823	0.8	1.2	72	1,040		Yes	Restricted
Sacramento River	47.9 R	1,031	3.1	13,365	9,317	1.9	1.1	140	928		Yes	Unrestricted
Sacramento River	48.2 R	1,039	2.4	13,930	8,774	1.0	1.4	107	935		Yes	Restricted
Sacramento River	62.5 R	255	0.6	5,138	2,361	0.3	0.4	40	230		Yes	Unrestricted
Sacramento River	68.9 L	786	1.9	10,189	10,946	0.4	1.5	50	707		Yes	Unrestricted
Sacramento River	78.0 L	1,058	1.9	10,698	11,756	0.4	1.5	20	952		Yes	Unrestricted
Steamboat Slough	19.0 R	552	0.9	2,044	5,111	0.3	0.6	98	NA	Yes	Yes	Restricted
Steamboat Slough	19.4 R	272	0.4	967	1,612	0.1	0.3	12	NA	Yes	Yes	Restricted
Steamboat Slough	22.7 R	222	0.4	1,842	2,138	0.2	0.2	35	NA	Yes	Yes	Restricted
Total	**14 sites**	**9,817**	**21.7**	**116,743**	**97,182**	**8.4**	**13.3**	**952**	**7,705**	**5 sites**	**14 sites**	**10 Res/4 Ures**

C. Project Operation and Maintenance

Operation and Maintenance (O&M) activities that may be necessary for three to five years to maintain the flood control and environmental values at the site include removing invasive vegetation determined to be detrimental to the success of the project, pruning and watering planted vegetation to promote optimal growth, replacing vegetation plantings, monitoring navigational hazards, and placing fill and rock revetment if the site is damaged during high flow events or vandalism.

Maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the project are positive, as determined by the SAM. This approach will adaptively manage project conservation measures based on SAM modeling, monitoring, and professional judgment. Once established, the riparian vegetation is expected to be self-maintaining. Annual placement of the bank protection material would require no more than 600 cubic yards of material per site, per year. If more than 600 cubic yards per site need to be placed in any year, the operating and maintaining agency would consult separately with NMFS through the Corps regulatory division.

In coordination with Federal and State resource agencies, any in-water work would be conducted during appropriate time periods to avoid adverse impacts to fish. The current proposed in-water work window is July 1 to October 30.

The Corps will, within 12 months of the onset of construction of the proposed bank protection actions prepare a detailed O&M plan for the bank protection actions and any additional or off-site mitigation that may be required. The Corps shall at a minimum take yearly photos of the sites in two locations (*i.e.*, upstream, downstream) to document site performance. The O&M plan shall ensure that riparian vegetation and anchored IWM are maintained and, pending the results of monitoring, adaptively managed to ensure their conservation value. If O&M activities identify new technologies to enhance habitat values for Federally listed fish species, they will be considered for wider application to other eroding sites in the SRBPP action area. Should the conservation measures fail, or be demonstrated as harmful to any Federally listed species, the Corps may request NMFS to consider allowing the O&M practices to lapse or for conservation measures to be implemented using modified techniques or at other locations.

D. Proposed Minimization and Conservation Measures

The Corps will incorporate the following additional measures into the project design, to help conserve and minimize impacts to listed species:

- Stockpiling of construction materials, including portable equipment, vehicles and supplies, including chemicals, shall be restricted to the designated construction staging areas and barges, exclusive of any riparian and wetlands areas.

- Erosion control measures (*i.e.*, Best Management Practices [BMPs]) that prevent soil or sediment from entering the river shall be placed, monitored for effectiveness, and maintained throughout the construction operations.

- All litter, debris, unused materials, equipment, and supplies shall be removed daily from any areas below the ordinary high water line daily and deposited at an appropriate disposal or storage site.

- Any spills of hazardous materials shall be cleaned up immediately and reported to the resource agencies within 24 hours. Any such spills, and the success of the efforts to clean them, shall also be reported in post-construction compliance reports.

- A representative shall be appointed by the Corps who shall be the point-of-contact for any Corps employee, or contractor, or contractor employee, who might incidentally take a living, or find a dead, injured, or entrapped threatened and endangered species during project construction and operations. This representative shall be identified to the employees and contractors during an all-employee education program conducted by the Corps relative to the various Federally listed species which may be encountered on the construction sites.

- If requested by the resource agencies, during or upon completion of construction activities, the Corps biologist/environmental manger or contractor shall accompany USFWS or NMFS personnel on an on-site, post-construction inspection tour to review project impacts and restoration success.

- The intakes for any water pumps needed for the construction process shall be screened to NMFS salmonid-screening specifications.

- A Corps representative shall work closely with the contractor(s) through all construction stages to ensure that any living riparian vegetation or IWM within “vegetation clearing zones,” which can reasonably be avoided without compromising basic engineering design and safety, is avoided and left undisturbed to the extent feasible.

- Maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the project are positive, as determined by the SAM. This approach will adaptively manage project conservation measures based on SAM modeling, monitoring, and professional judgment. Language providing such assurance(s) shall be provided to the resource agencies for review and concurrence before formal O&M documents are finalized by the Corps, and written evidence of acceptance of such assurance language by the local maintaining agency or district, shall be provided to the resource agencies.

- A study of the efficacy of integrated conservation measures (*i.e.*, plantings in riprap, planting bench, and anchored IWM) shall be instituted for a minimum of 5 years following construction. Focus of the study shall include, but not be limited to, IWM input and retention, sediment and organic matter retention and storage, habitat creation, and actual usage of the features by Federally listed and other fishes. Annual reports, and a final report deriving conclusions as to biological efficacy of the features, shall be provided to NMFS and the USFWS within 90 days of the study conclusion.

Furthermore, the Corps will seek to avoid and minimize adverse effects to the extent feasible. There are a number of measures that will be applied to the entire project or specific aspects of the project and other measures that may be appropriate to implement at specific locations within the project footprint. Avoidance measures to be implemented during final design and construction may include, but are not limited to the following:

- Incorporate sensitive habitat information into project bid specifications.

- Fence sensitive habitats with orange construction fencing or similar material.

- Incorporate requirements for contractors to avoid identified sensitive habitats into project bid specifications.

- Minimize vegetation removal to the extent feasible, and leave as much existing IWM in place as possible, anchoring the IWM in place with rock.

- Perform no grubbing or contouring of the sites.

- Ensure all fill materials are placed with no excavation or movement of existing materials onsite.

- Ensure all construction activities; including clearing, pruning, and trimming of vegetation, is supervised by a qualified biologist to ensure these activities have a minimal effect on natural resources.

- If a cofferdam is needed during construction, it will be constructed by placing the sheet piles sequentially from the upstream to the downstream limits of the construction area (however, it is not anticipated at this time that a cofferdam will be needed). Prior to the closure of the cofferdam, seining will be conducted within the cofferdam with a small-mesh seine to direct fish out of the cofferdam and remove as many fish as possible. Upon completion of seining, exclusionary nets will be placed in the river to prevent fish from entering the cofferdam before the cofferdam is closed. When the cofferdam is partially dewatered, a final seining effort will be conducted within the cofferdam. Only low-flow pumps with screened intakes will be used during dewatering operations. If seining cannot rescue all listed species, a qualified fisheries biologist will use electrofishing to capture any remaining fish. All captured juvenile salmonids shall be released in the Sacramento River downstream of the construction area.

- Avoid direct and indirect effects on habitats containing or with a substantial possibility of containing listed terrestrial, wetland, and plant species to the extent feasible.

E. Proposed Compensation Measures

The Corps anticipates that the projects will largely be self-compensating due to the extensive environmental features proposed to maintain, protect, or create habitat features beneficial to anadromous salmonids. A final SAM analysis will be conducted after Phase 2. If this final SAM analysis, or other evaluations indicated uncompensated habitat impacts, the Corps will pursue further conservation measures, including off-site compensation.

F. Monitoring

The Corps will, within 90 days of the completion of construction, submit a detailed, site-specific monitoring plan for the resource agencies (NMFS USFWS, and CDFG) to review. The Corps proposes to apply this plan to the critical erosion repair sites, and other sites, as necessary for approximately 5 years following construction. The monitoring plan will be incorporated into the O&M manual and implemented at all project sites. Elements of the monitoring plan include photographic documentation, riparian vegetation, SRA, IWM, shallow water habitat, instream vegetative cover, bank substrate size, and fish use of project sites using boat-mounted electrofishing.

Monitoring is necessary to ensure that the vegetated benches, IWM structures, and other conservation measures are functioning as projected by the SAM model. The Corps shall submit a yearly report of monitoring results to the resource agencies by December 31 of each year. Monitoring is to be conducted until such time as the projected benefits of mitigation actions to Federally listed fish species can either be substantially confirmed or discounted. If integrated conservation measures fail to meet modeled SAM values, specific remedial measures for each type of conservation measure (*i.e.*, riparian survival and growth, IWM, benches) and the level of effort applied to implement such measures will be determined based on the magnitude and the causes of failure. Potential remedial measures may include: (1) planting additional vegetation at the project site, (2) placing additional IWM at the project site, (3) extending the irrigation period, (4) planting additional plants at offsite locations, and (5) placing additional IWM at offsite locations.

The Corps, with the assistance of the IWG and the ultimate approval of the resource agencies, also will develop a broader fisheries and aquatic ecosystem monitoring plan for the project area. Larger-scale aquatic monitoring is necessary to ensure that the various experimental on-site mitigation features are functioning in a way that enhances habitat value and offsets adverse levee repair effects. Monitoring also is necessary to determine any adverse effects associated with the loss of river function and increased habitat fragmentation associated with the project. Monitoring will evaluate the effectiveness any restoration measures implemented to restore natural fluvial function (*i.e.*, set-back levees, restoration of eroding banks, etc.). The results of large-scale monitoring will be used to develop future minimization measures and conservation ratios with respect to Federally listed species and will help determine whether the emergency levee repair mitigation features require long-term maintenance or must be modified to reduce unforeseen adverse impacts on listed species and the ecosystems in which they occur.

G. Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). The action area, for the purposes of this biological opinion includes the Sacramento River from RM 78.0 downstream to RM 20, including Steamboat Slough from RM 22.7 downstream to the confluence with the Sacramento River. This area was selected because it represents the upstream and downstream extent of anticipated project actions, including potential off-site compensation actions.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species evolutionary significant units (ESU) or distinct population segments (DPS) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*) endangered (June 28, 2005, 70 FR 37160)
Sacramento River winter-run Chinook salmon designated critical habitat (June 16, 1993, 58 FR 33212)
Central Valley spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*) threatened (June 28, 2005, 70 FR 37160)
Central Valley spring-run Chinook salmon designated critical habitat (September 2, 2005, 70 FR 52488)
Central Valley steelhead DPS (*Oncorhynchus mykiss*) threatened (December 22, 2005)
Central Valley steelhead designated critical habitat (September 2, 2005, 70 FR 52488)
Southern DPS of North American green sturgeon (*Acipenser medirostris*) threatened (April 7, 2006, 70 FR 17386)

A. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. Chinook Salmon

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

Information on the migration rates of Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin where information regarding migration behavior is needed to assess the effects of dams on travel times and passage (Matter *et al*. 2003). Keefer *et al.* (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter *et al*. (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion while migrating upstream (CALFED Science Program 2001) several days at a time. Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins (Stillwater Sciences 2004), particularly larger salmon such as Chinook, as described by Hughes (2004). Adults are thought to exhibit crepuscular behavior during their upstream migrations; meaning that they primarily are active during twilight hours. Recent hydroacoustic monitoring conducted by LGL Environmental Research Associates showed peak upstream movement of adult CV spring-run Chinook salmon in lower Mill Creek, a tributary to the Sacramento River, occurring the in the four hour period before sunrise and again after sunset.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995). Upon emergence, fry swim or are displaced downstream (Healey 1991). Similar to adult movement, juvenile salmonid downstream movement is crepuscular. Documents and data provided to NMFS in support of ESA section 10 research permit applications depicts that the daily migration of juveniles passing RBDD is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in the stream for a period of time from weeks to a year (Healey 1991).

Fry then seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Meyer 1979, Healey 1980). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, MacFarlane and Norton 2001, Sommer *et al.* 2001).

As juvenile Chinook salmon grow they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures (Healey 1991). Catches of juvenile salmon in the Sacramento River near West Sacramento by the USFWS (1997) exhibited larger juvenile captures in the main channel and smaller sized fry along the margins. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1980). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration (Kjelson *et al*. 1982, Brandes and McLain, 2001).

Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al*. (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Sommer *et al.* (2001) found rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1981).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1981, Healey 1991). Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Juvenile Chinook salmon were found to spend about 40 days migrating through the Sacramento-San Joaquin Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallone Islands (MacFarlane and Norton 2001). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2001) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

a. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon originally were listed as threatened in August 1989, under emergency provisions of the Endangered Species Act (ESA), and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. NMFS reaffirmed the listing of Sacramento River winter-run Chinook salmon as endangered on June 28, 2005 (70 FR 37160). The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212).

Sacramento River winter-run Chinook salmon adults enter the Sacramento River basin between December and July; the peak occurring in March (Table 2, Yoshiyama *et al*. 1998, Moyle 2002). Spawning occurs primarily from mid April to mid August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick dam and Red Bluff Diversion Dam (RBDD) (Vogel and Marine 1991). The majority of Sacramento River winter-run Chinook salmon spawners are 3 years old.

Sacramento River winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence generally occurring at night. Post-emergent fry disperse to the margins of the river, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on small insects and crustaceans.

Emigration of juvenile Sacramento River winter-run Chinook salmon past RBDD may begin as early as mid July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all Sacramento River winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). Juvenile Sacramento River winter-run Chinook salmon occur in the Delta primarily from November through early May based on data collected from trawls in the Sacramento River at West Sacramento (RM 57) (USFWS 2001). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Winter-run Chinook salmon juveniles remain in the Delta until they reach a fork length of approximately 118 mm and are from 5 to 10 months of age, and then begin emigrating to the ocean as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998).

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stems primarily from the following: (1) ESA section 7 consultation Reasonable and Prudent Alternatives on temperature, flow, and operations of the CVP and SWP; (2) Regional Board decisions requiring compliance with Sacramento River water temperature objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from the California Bay Delta Authority (CALFED) Bay-Delta Program (*e.g.*, installation of a fish screen on the Glenn Colusa Irrigation District (GCID) diversion); (5) establishment of the CALFED Environmental Water Account

(EWA); (6) Environmental Protection Agency actions to control acid mine runoff from Iron Mountain Mine; and, (7) ocean harvest restrictions implemented in 1995.

Table 2. The temporal occurrence of adult (a) and juvenile (b) Sacramento River winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[1]												
Sac. River[2]												

b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River @ Red Bluff[3]												
Sac. River @ Red Bluff[2]												
Sac. River @ Knights L.[4]												
Lower Sac. River (seine)[5]												
West Sac. River (trawl)[5]												

Source: [1]Yoshiyama *et al*. 1998; Moyle 2002; [2]Myers *et al*. 1998; [3]Martin *et al.* 2001; [4]Snider and Titus 2000; [5]USFWS 2001

Relative Abundance: = High = Medium = Low

Historical Sacramento River winter-run Chinook salmon population estimates, which included males and femails, were as high as near 100,000 fish in the 1960s; however, populations monotonically declined to under 200 fish in the 1990s (Good *et al.* 2005). Population estimates in 2003 (8,218), 2004 (7,701), and 2005 (15,730) show a recent increase in the population size (California Department of Fish and Game [CDFG] Grandtab, February 2005, letter titled “Winter-run Chinook Salmon Escapement Estimates for 2005” from CDFG to NMFS, January 13, 2006) and a 3-year average of 10,550. The 2005 run was the highest since the listing. Overall, abundance measures suggest that the abundance is increasing (Good *et al*. 2005). Two current methods are utilized to estimate the juvenile production of Sacramento River winter-run Chinook salmon: the Juvenile Production Estimate (JPE) method, and the Juvenile Production Index (JPI) method (Gaines and Poytress 2004). Gaines and Poytress (2004) estimated the juvenile population of Sacramento River winter-run Chinook salmon exiting the upper Sacramento River at RBDD to be 3,707,916 juveniles per year using the JPI method between the years 1995 and 2003 (excluding 2000 and 2001). Using the JPE method, they estimated an average of 3,857,036 juveniles exiting the upper Sacramento River at RBDD between the years of 1996 and 2003 (Gaines and Poytress 2004). Averaging these 2 estimates yields an estimated population size of 3,782,476.

Based on the RBDD counts, the population has been growing rapidly since the 1990s with positive short-term trends. An age-structured density-independent model of spawning escapement by Botsford and Brittnacker in 1998 (as referenced in Good *et al*. 2005) assessing the viability of Sacramento River winter-run Chinook salmon found the species was certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with fewer than 50 females (Good *et al*. 2005). Lindley *et al*. (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the status of the Sacramento River winter-run Chinook salmon population is improving, there is only one population, and it depends on cold-water releases from Shasta Dam, which could be vulnerable to a prolonged drought (Good *et al*. 2005). Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the draft recovery goals established for the run (NMFS 1997, 1998) and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the recovery criteria for Sacramento River winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females (NMFS with a concurrent geometric mean of the cohort replacement rate greater than 1.0 (NMFS 1997). Recent trends in Sacramento River winter-run Chinook salmon abundance and cohort replacement remain positive, indicating some recovery since the listing. However, the population remains well below the recovery goals of the draft recovery plan, and is particularly susceptible to extinction because of the reduction of the genetic pool to one population.

b. *Central Valley Spring-run Chinook Salmon*

NMFS listed the CV spring-run Chinook salmon ESU as threatened on September 16, 1999 (64 FR 50394). In June 2004, NMFS proposed that CV spring-run Chinook salmon remain listed as threatened (69 FR 33102). This proposal was based on the recognition that although CV spring-run Chinook salmon productivity trends are positive, the ESU continues to face risks from having a limited number of remaining populations (*i.e.*, 3 existing populations from an estimated 17 historical populations), a limited geographic distribution, and potential hybridization with Feather River Hatchery (FRH) spring-run Chinook salmon, which until recently were not included in the ESU and are genetically divergent from other populations in Mill, Deer, and Butte Creeks. On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV spring-run Chinook salmon as threatened (70 FR 37160). This decision also included the FRH spring-run Chinook salmon population as part of the CV spring-run Chinook salmon ESU. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488).

Adult Central Valley spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (Table 3, Yoshiyama *et al*. 1998, Moyle 2002). Lindley *et al*. (2006a) indicates adult Central Valley spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid April and mid June. Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al*. 1998).

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the year or as juveniles or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al*. 2006a). Studies in Butte Creek (McReynolds *et al*. 2005, Ward *et al*. 2002, 2003) found the majority of Central Valley spring-run Chinook salmon migrants to be fry occurring primarily during December, January and February; and that these movements appeared to be influenced by flow. Small numbers of Central Valley spring-run Chinook salmon remained in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer Creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer Creek juveniles typically exhibit a later young-of-the year migration and an earlier yearling migration (Lindley *et al*. 2006a).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). Peak movement of juvenile Central Valley spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April; however, juveniles also are observed between November and the end of May (Snider and Titus 2000).

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon are spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock. The number of naturally-spawning spring-run

Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (Good *et al*. 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance.

Table 3. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
[1,2]Sac.River basin			Medium	Medium	High	High	Medium	Medium	Medium			
[3]Sac. River			Medium	Medium	Medium	Medium	Medium					
[4]Mill Creek			Low	Medium / High	High	High / Medium	Medium / Low	Low / –				
[4]Deer Creek			Low	Medium / High	High	High / Medium	Medium / –					
[4]Butte Creek		Medium	Medium	Medium	Medium	Medium	Medium					

(b) Juvenile

Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
[5]Sac. River Tribs	Medium	Medium	Medium							Medium	High	High
[6]Upper Butte Creek	High	High	Medium	Medium	Medium	Low				Low	Low	High
[4]Mill, Deer, Butte Creeks	High	High	Medium	Medium	Medium	Low				Low	Low	Low
[3]Sac. River at RBDD	High	Low	Low	Low							High	High
[7]Sac. River at KL	Medium	Medium	High	High	Medium						Medium	High

Source:[1]Yoshiyama *et al*. 1998; [2]Moyle 2002; [3]Myers *et al*. 1998; [4]Lindley *et al*. 2006a; [5]CDFG 1998;
[6]McReynolds *et al*. 2005; Ward *et al*. 2002, 2003; [7]Snider and Titus 2000

Relative Abundance: ■ = High ■ = Medium ■ = Low

Central Valley spring-run Chinook salmon were once the most abundant run of salmon in the Central Valley (Campbell and Moyle 1992) and were found in both the Sacramento and San Joaquin drainages. More than 500,000 Central Valley spring-run Chinook salmon were caught in the Sacramento-San Joaquin commercial fishery in 1883 alone (Yoshiyama *et al.* 1998). The San Joaquin populations essentially were extirpated by the 1940s, with only small remnants of the run that persisted through the 1950s in the Merced River (Yoshiyama *et al.* 1998).

Populations in the upper Sacramento, Feather, and Yuba Rivers were eliminated with the construction of major dams during the 1950s and 1960s. Naturally spawning populations of Central Valley spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Mill Creek, Feather River, and the Yuba River (CDFG 1998).

The Central Valley spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. The average abundance for the ESU was 12,590 for the period of 1969 to 1979, 13,334 for the period of 1980 to 1990, 6,554 from 1991 to 2001, and 16,349 between 2002 and 2005 (for the purposes of this biological opinion, the average adult population is assumed to be 16,349 until new information is available. Sacramento River tributary populations in Mill, Deer, and Butte Creeks are probably the best trend indicators for the Central Valley spring-run Chinook ESU as a whole because these streams contain the primary independent populations with the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995. During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although recent trends are positive, annual abundance estimates display a high level of fluctuation, and the overall number of Central Valley spring-run Chinook salmon remains well below estimates of historic abundance. Additionally, in 2003, high water temperatures, high fish densities, and an outbreak of Columnaris Disease (*Flexibacter Columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) contributed to the pre-spawning mortality of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek.

Several actions have been taken to improve habitat conditions for Central Valley spring-run Chinook salmon, including: improved management of Central Valley water (*e.g.*, through use of CALFED EWA and CVPIA (b)(2) water accounts); implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries; and, changes in ocean and inland fishing regulations to minimize harvest. Although protective measures likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally spawned and hatchery fish, run hybridization and genomic homogenization), climatic variation, high temperatures, predation, and water diversions still persist.

The time series of abundance for Mill, Deer, Butte, and Big Chico creeks Central Valley spring-run Chinook salmon were updated through 2001 by Good *et al*. (2005). These time series show that the increases in population that started in the early 1990s have continued. During this period, there have been significant habitat improvements (including the removal of several small dams and increases in summer flows) in these watersheds, as well as reduced ocean fisheries and a favorable terrestrial and marine climate. It appears that the three spring-run Chinook salmon populations in the Central Valley are growing (Good *et al*. 2005). All three spring-run Chinook salmon populations have signs of positive long- and short-term mean annual population growth rates. Although Central Valley spring-run Chinook salmon have some of the highest population growth rates in the Central Valley, other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall-run Chinook salmon populations (Good *et al*. 2005). Because the Central Valley spring-run Chinook salmon ESU is spatially confined to relatively few remaining streams, continues to display broad fluctuations in abundance, and a large proportion of the population (*i.e*., in Butte Creek) faces the risk of high mortality rates, the population remains at a moderate to high risk of extinction.

2. <u>Central Valley Steelhead</u>

Central Valley steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River basins in California's Central Valley. In June 2004, NMFS proposed that CV spring-run Chinook salmon remain listed as threatened (69 FR 33102). On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV steelhead as threatened (70 FR 37160). This decision also included the Coleman National Fish Hatchery and FRH steelhead populations. These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for CV steelhead on September 2, 2005 (70 FR 52488).

Steelhead can be divided into two life history types, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.*, summer (stream-maturing) and winter (ocean-maturing) steelhead). Only winter steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

Central Valley steelhead generally leave the ocean from August through April (Busby *et al.* 1996), and spawn from December through April with peaks from January though March in small streams and tributaries where cool, well oxygenated water is available year-round (McEwan and Jackson 1996, Hallock *et al.* 1961) (Table 4). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

The female selects a site where there is good intergravel flow, then digs a redd and deposits eggs while an attendant male fertilizes them. The eggs are then covered with gravel when the female begins excavation of another redd just upstream. The length of time it takes for eggs to hatch depends mostly on water temperature. Hatching of steelhead eggs in hatcheries takes about 30 days at 51 °F. Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Newly emerged fry move to the shallow, protected areas associated with the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating Central Valley steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile Central Valley steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle 2002).

Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Nobriga and Cadrett (2003) also have verified these temporal findings based on analysis of captures at Chipps Island, Susuin Bay.

Central Valley steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996) and were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). Lindley *et al*. (2006b) estimated that historically there were at least 81 indpendant CV steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin Rivers. This distribution has been greatly affected by dams (McEwan and Jackson 1996). Presently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of historical populations (Lindley *et al*. 2006b).

Historic Central Valley steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially. Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Recent estimates from trawling data in the Delta indicate that approximately 100,000 to 300,000 (mean 200,000) smolts emigrate to the ocean per year representing approximately 3,600 female Central Valley steelhead spawners in the Central Valley basin (Good *et al*. 2005). This can be compared with McEwan's (2001) estimate of one million to two million spawners before 1850, and 40,000 spawners in the 1960s.

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996). Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, USFWS, pers. comm. 2002, as reported in Good *et al*. 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, Central Valley steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001).

It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005). CDFG staff have prepared juvenile migrant Central Valley steelhead catch summaries on the San Joaquin River near Mossdale representing migrants from the Stanislaus, Tuolumne, and Merced Rivers. Based on trawl recoveries at Mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG staff stated that it is “clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River” (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003). The documented returns on the order of single fish in these tributaries suggest that existing populations of Central Valley steelhead on the Tuolumne, Merced, and lower San Joaquin Rivers are severely depressed.

Table 4. The temporal occurrence of adult (a) and juvenile (b) Central Valley steelhead in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,3]Sac. River												
[2,3]Sac R at Red Bluff												
[4]Mill, Deer Creeks												
[6]Sac R. at Fremont Weir												
[6]Sac R. at Fremont Weir												
[7]San Joaquin River												

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2]Sacramento River												
[2,8]Sac. R at Knights Land												
[9]Sac. River @ KL												
[10]Chipps Island (wild)												
[8]Mossdale												
[11]Woodbridge Dam												
[12]Stan R. at Caswell												
[13]Sac R. at Hood												

Source: [1]Hallock 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG 1995; [5]Hallock *et al*. 1957; [6]Bailey 1954; [7]CDFG Steelhead Report Card Data; [8]CDFG unpublished data; [9]Snider and Titus 2000; [10]Nobriga and Cadrett 2003; [11]Jones & Stokes Associates, Inc., 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980

Relative Abundance: = High = Medium = Low

Lindley *et al*. (2006b) indicated that prior population census estimates completed in the 1990s found the Central Valley steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). The future of Central Valley steelhead is uncertain due to limited data concerning their status. Central Valley steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates.

3. <u>Southern DPS of North American Green Sturgeon</u>

The Southern DPS of North American green sturgeon was listed as threatened on April 7, 2006, (70 FR 17386) and includes the North American green sturgeon population spawning in the Sacramento River and utilizing the Sacramento River, the Delta, and the San Francisco Estuary.

North American green sturgeon are widely distributed along the Pacific Coast and have been documented offshore from Ensenada Mexico to the Bering Sea and found in rivers from British Columbia to the Sacramento River (Moyle 2002). As is the case for most sturgeon, North American green sturgeon are anadromous; however, they are the most marine-oriented of the sturgeon species (Moyle 2002). In North America, spawning populations of the anadromous green sturgeon currently are found in only three river systems, the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon.

Two green sturgeon DPSs were identified based on evidence of spawning site fidelity (indicating multiple DPS tendencies), and on the preliminary genetic evidence that indicates differences at least between the Klamath River and San Pablo Bay samples (Adams *et al*. 2002). The Northern DPS includes all green sturgeon populations starting with the Eel River and extending northward. The Southern DPS would include all green sturgeon populations south of the Eel River with the only known spawning population being in the Sacramento River.

The Southern DPS of North American green sturgeon life cycle can be broken into four distinct phases based on developmental stage and habitat use: (1) adult females greater than or equal to 13 years of age and males greater than or equal to 9 years of age, (2) larvae and post-larvae less than 10 months of age, (3) juveniles less than or equal to 3 years of age, and (4) coastal migrant females between 3 and 13, and males between 3 and 9 years of age (Nakamoto *et al*. 1995, (Jeff McLain, NMFS, pers. comm., 2006).

New information regarding the migration and habitat use of the Southern DPS of North American green sturgeon has emerged. Lindley (2006c) presents preliminary results of large-scale green sturgeon migration studies. Lindley's analysis verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. It appears North American green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia. This information also agrees with the results of green sturgeon tagging studies completed by CDFG where they tagged a total of 233 green sturgeon in the San Pablo Estuary between 1954 and 2001. A total of

17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of Oregon and Washington. Eight of the 12 recoveries were in the Columbia Estuary (CDFG 2002). In addition, recent analysis by Israel (2006a) indicates a substantial component of the population (*i.e.*, 50-80 percent). of Southern DPS North American green sturgeon to be present in the Columbia estuary.

Kelley *et al.* (2006) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn. The authors studied the movement of adults in the San Francisco Estuary and found them to make significant long-distance movements with distinct directionality. The movements were not found to be related to salinity, current, or temperature and the authors surmised they are related to resource availability (Kelley *et al*. 2006). Green sturgeon were most often found at depths greater than 5 meters with low or no current during summer and autumn months (Erickson *et al*. 2002). The majority of green sturgeon in the Rogue River emigrated from freshwater habitat in December after water temperatures dropped (Erickson *et al*. 2002). The authors surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Based on captures of adult green sturgeon in holding pools on the Sacramento River above the GCID diversion (RM 205) and the documented presence of adults in the Sacramento River during the spring and summer months and the presence of larval green sturgeon in late summer in the lower Sacramento River indicating spawning ocurrence, it appears adult green sturgeon could possibly utilize a variety of freshwater and brackish habitats for up to nine months of the year (Ray Beamesderfer, S.P. Cramer & Associates, Inc., pers. comm. 2006).

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, Adams *et al*. 2002, Jeffrey Stuart, NMFS, pers. comm. 2006). Adult sturgeon caught in Washington State waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

Based on the distribution of sturgeon eggs, larva, and juveniles in the Sacramento River, CDFG (2002) indicated that Southern DPS of green sturgeon spawn in late spring and early summer above Hamilton City possibly to Keswick Dam. Adult green sturgeon are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (*i.e.*, 10 to 15 years based on sympatric white sturgeon sexual maturity (CDFG 2002). Adult female green sturgeon produce between 60,000 and 140,000 eggs each reproductive cycle, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al*. 2001). Southern DPS Green sturgeon adults begin their upstream spawning migrations into the San Francisco Bay in March, reach Knights Landing during April, and spawn between March and July (Heublein *et al*. 2006). Peak spawning is believed to occur between April and June (Table 4) and thought to occur in deep turbulent pools (Adams *et al*. 2002). Substrate is likely large cobble but can range from clean sand to bedrock (USFWS 2002). Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length. According to Heublein (2006) all adults leave the Sacramento River prior to September 1.

After approximately 10 days, larvae begin feeding, growing rapidly, and young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002). Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in June and July at lengths ranging from 24 to 31 mm fork length (CDFG 2002, USFWS 2002). The mean yearly total length of post-larval green sturgeon captured in rotary screw traps at the RBDD ranged from 26 mm to 34 mm between 1995 and 2000 indicating they are approximately 2 weeks old. The mean yearly total length of post-larval green sturgeon captured in the GCID rotary screw trap, approximatley 30 miles downstream of RBDD ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, unpublished data) indicating they are approximately 3 weeks old (Van Eenennaam *et al*. 2001).

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other Acipenseridae. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al*. 2001). After six days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al*.'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first six months of life. When ambient water temperatures reached 46 ^{o}F, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9-to 10-month-old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Facility (Fish Facilities) in the South Delta, and captured in trawling studies by the CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 and 500 mm indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto *et al*. (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicates juvenile Southern DPS North American green sturgeon likely hold in the mainstem Sacramento River as suggested by Kyndard *et al*. (2005).

Population abundance information concerning the Southern DPS green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002, NMFS 2005a). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). CDFG (2002) utilizes a multiple-census or Peterson mark-recapture method to estimate the legal population of white sturgeon captures in trammel nets. By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al*. 2002). The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386). Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the portion of the Southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay which is known to consist of a mixture of Northern and Southern DPS North American green sturgeon. Recent spawning population estimates using sibling based genetics by Israel (2006b) indicates a maximum spawning population of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71). Based on the length and estimated age of post-larvae captured at RBDD (approximately two weeks of age) and GCID (downstream; approximately three weeks of age), it appears the majority of Southern DPS North American green sturgeon are spawning above RBDD. Note, there are many assumptions with this interpretation (*i.e*., equal sampling efficiency and distribution of post-larvae across channels) and this information should be considered cautiously.

There are at least two records of confirmed adult sturgeon observation in the Feather River (Beamesderfer *et al*. 2004), however, there are no observations of juvenile or larval sturgeon even prior to the 1960s when Oroville Dam was built (NMFS 2005a). There are also unconfirmed reports that green sturgeon may spawn in the Feather River during high flow years (CDFG 2002).

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the European settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for over a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of Central Valley spring-run Chinook salmon and Central Valley steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning (Lindley *et al*. 2006b) suggests that significant potential green sturgeon spawning habitat was made inaccessible or altered by dams (historical habitat characteristics, temperatures, and geology summarized). This spawning habitat may have extended up into the three major branches of the Sacramento River; the Little Sacramento River, the Pitt River system, and the McCloud River (NMFS 2005a). Due to substantial habitat loss as well as existing threats to the Southern DPS of North American green sturgeon, it continues to remain at a moderate to high risk of extinction.

Table 5. The temporal occurrence of adult (a) larval and post-larval (b) juvenile (c) and coastal migrant (d) Southern DPS of North American green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

(a) Adult (≥13 years old for females and ≥9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2,3]Upper Sac. River												
[4,8]SF Bay Estuary												

(b) Larval and post-larval (≤10 months old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]RBDD, Sac River												
[5]GCID, Sac River												

(c) Juvenile (> 10 months old and ≤3 years old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[6]South Delta*												
[6]Sac-SJ Delta												
[5]Sac-SJ Delta												
[5]Suisun Bay												

(d) Coastal migrant (3-13 years old for females and 3-9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[3,7]Pacific Coast												

Source: [1]USFWS 2002; [2]Moyle *et al*. 1992; [3]Adams *et al*. 2002 and NMFS 2005a; [4]Kelley *et al*. 2006; [5]CDFG 2002; [6]Interagency Ecological Program Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [7]Nakamoto *et al*. 1995; [8]Heublein *et al*. 2006

* Fish Facility salvage operations

Relative Abundance: = High = Medium = Low

The freshwater habitat of North American green sturgeon in the Sacramento-San Joaquin drainage varies in function, depending on location. Spawning areas currently are limited to accessible upstream reaches of the Sacramento River. Preferred spawning habitats are thought to contain large cobble in deep cool pools with turbulent water (CDFG 2002, Moyle 2002).

Migratory corridors are downstream of the spawning areas and include the mainstem Sacramento River and the Estuary and Delta. These corridors allow the upstream passage of adults and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers which can include dams, unscreened or poorly screened diversions, and degraded water quality. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their 1 to 3 year residence in freshwater. Rearing habitat condition and function may be affected by variation in annual and seasonal flow and temperature characteristics.

B. Critical Habitat and Primary Constituent Elements

The designated critical habitat for Sacramento River winter-run Chinook salmon includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Estuary to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge. In the Sacramento River, critical habitat includes the river water column, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. In the areas westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by Sacramento River winter-run Chinook salmon as part of their juvenile emigration or adult spawning migration.

Critical habitat for Central Valley spring-run Chinook salmon includes stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River and Delta. Critical Habitat for Central Valley steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; and, the San Joaquin River its tributaries, and the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (70 FR 52488). Critical habitat for Central Valley spring-run Chinook salmon and steelhead is defined as specific areas that contain the primary constituent elements (PCE) and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for Central Valley spring-run Chinook salmon and Central Valley steelhead, and as physical habitat elements for Sacramento River winter-run Chinook salmon.

1. Spawning Habitat

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the Central Valley for Chinook salmon and steelhead is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for Sacramento River winter-run Chinook salmon is restricted to the Sacramento River primarily between RBDD and Keswick Dam. Central Valley spring-run Chinook salmon also spawn on the mainstem Sacramento River between RBDD and Keswick Dam and in tributaries such as Mill, Deer, and Butte Creeks. Spawning habitat for Central Valley steelhead is similar in nature to the requirements of Chinook salmon, primarily occurring in reaches directly below dams (*i.e*., above RBDD on the Sacramento River) throughout the Central Valley. Spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

2. Freshwater Rearing Habitat

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (*e.g.*, the lower Cosumnes River, Sacramento River reaches with set-back levees [*i.e.*, primarily located upstream of the City of Colusa]). However, the channeled, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Freshwater rearing habitat also has a high conservation value as the juvenile life stage of salmonids is dependant on the function of this habitat for successful survival and recruitment.

3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of obstruction with water quantity and quality conditions and contain natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility, survival and food supply. Migratory corridors are downstream of the spawning area and include the lower Sacramento River and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams, unscreened or poorly- screened diversions, and degraded water quality. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high conservation value.

4. Estuarine Areas

Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large wood, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas contain a high conservation value as they function as predator avoidance and as a transition to the ocean environment.

C. Factors Affecting the Species and Critical Habitat

1. Chinook Salmon and Central Valley Steelhead

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley. For example, NMFS prepared range-wide status reviews for west coast Chinook salmon (Myers *et al*. 1998) and steelhead (Busby *et al*. 1996). Also, the NMFS Biological Review Team (BRT) published a draft updated status review for west coast Chinook salmon and steelhead in November 2003 (NMFS 2003), and an additional updated and final draft in 2005 (Good *et al*. 2005). NMFS also assessed the factors for Chinook salmon and steelhead decline in supplemental documents (NMFS 1996, 1998). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212; 59 FR 440; 62 FR 24588; 62 FR 43937; 63 FR 13347; 64 FR 24049; 64 FR 50394; 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Program (CALFED 2000), and the Final Programmatic EIS for the CVPIA provide a summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley. The following general description of the status of species for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead is based on a summarization of these documents.

In general, the human activities that have affected listed anadromous salmonids and the PCEs of their critical habitats consist of: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) over-utilization; (3) disease or predation; and, (4) other natural and manmade factors.

a. *The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range*

(1) *Habitat Blockage*

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds resulting in the complete loss of substantial portions of spawning, rearing, and migration PCEs. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat actually was available before dam construction and mining, and concluded that 82 percent is not accessible today. Yoshiyama *et al*. (1996) surmised that steelhead habitat loss was even greater than salmon loss, as steelhead migrated farther into drainages. The California Advisory Committee on Salmon and Steelhead Trout (1988) estimated that there has been a 95 percent reduction of Central Valley anadromous fish spawning habitat.

In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of their respective watersheds. On the Sacramento River, Keswick Dam blocks passage to historic spawning and rearing habitat in the upper Sacramento, McCloud, and Pit Rivers. Whiskeytown Dam blocks access to the upper watershed of Clear Creek. Oroville Dam and associated facilities block passage to the upper Feather River watershed. Nimbus Dam blocks access to most of the American River basin. Friant Dam construction in the mid 1940s has been associated with the elimination of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River. On the Stanislaus River, construction of Goodwin Dam (1912), Tulloch Dam (1957), and New Melones Dam (1979) blocked both spring- and fall-run Chinook salmon as well as Central Valley steelhead. Similarly, La Grange Dam (1893) and New Don Pedro Dam (1971) blocked upstream access to salmonids on the Tuolumne River. Upstream migration on the Merced River was blocked in 1910 by the construction of Merced Falls and Crocker-Huffman Dams and later New Exchequer Dam (1967) and McSwain Dam (1967).

Changes in the thermal profiles and hydrographs of the Central Valley rivers presumably have subjected salmonids to strong selective forces (Slater 1963). The degree to which current life history traits reflect predevelopment characteristics is largely unknown, especially since most of the habitat degradation occurred before salmonid studies were undertaken late in the nineteenth century. Increased temperatures as a result of reservoir operations during winter and fall can affect emergence rates of Chinook salmon; thereby significantly altering the life history of a species (CALFED 2005). Shifts in life history have the potential to seriously affect survival (CALFED 2005).

Central Valley Chinook salmon exhibit an ocean-type life history; large numbers of juvenile Chinook salmon emigrate during the winter and spring (Kjelson *et al*. 1982, Gard 1995). High summer water temperatures in the lower Sacramento River (temperatures in the Delta can exceed

72 °F) create a thermal barrier to up- and downstream migration and may be partially responsible for the evolution of the fry migration life history (Kjelson *et al*. 1982).

The distribution of Sacramento River winter-run Chinook salmon spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams allowed for spawning, egg incubation, and rearing in cold water (Slater 1963, Yoshiyama *et al.* 1998). The headwaters of the McCloud, Pit, and Little Sacramento Rivers, and Hat and Battle Creeks, historically provided clean, loose gravel; cold, well-oxygenated water; and, optimal stream flows in riffle habitats for spawning and incubation. These areas also provided the cold, productive waters necessary for egg and fry development and survival, and juvenile rearing over the summer. The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which has its own impediments to upstream migration (*i.e.*, the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir) (Moyle *et al.* 1989; NMFS 1997). Approximately, 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run Chinook salmon. Yoshiyama *et al.* (2001) estimated that in 1938, the Upper Sacramento had a "potential spawning capacity" of 14,303 redds. Most components of the winter-run Chinook salmon life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River.

The initial factors that led to the decline of Central Valley spring-run Chinook salmon in the Central Valley also were related to the loss of upstream habitat behind impassable dams. Since spring-run Chinook salmon adults must hold over for months in small tributaries before spawning, they are much more susceptible to the effects of high water temperatures. The loss of upstream habitat had required Central Valley spring-run Chinook salmon to less hospitable reaches below dams.

The loss of subsantiail habitat above dams also has resulted in decreased juvenile and adult steelhead survival during migration, and in many cases, had resulted in the dewatering and loss of important spawning and rearing habitats.

(2) ***Water Diversion***

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted stream flows and altered the natural cycles by which juvenile and adult salmonids have evolved. Changes in stream flows and diversions of water affect spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta has been diverted for human uses. Depleted flows have contributed to higher temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and instream woody material (IWM). More uniform flows year-round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement, caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams. In addition, Brown and May (2000) found stream regulation to be associated with declines in benthic macroinvertebrate communities in Central Valley rivers. Macroinvertebrates are key prey species for salmonids.

Water withdrawals, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude to result in reverse flows in the lower San Joaquin River (Reynolds *et al*. 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival (Brandes and McLain 2001). Water temperatures in the Sacramento River have limited the survival of young salmon. Juvenile fall run Chinook salmon survival in the Sacramento River is also directly related with June streamflow and June and July delta outflow (Dettman *et al*. 1987).

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Hundreds of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001).

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP/SWP. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the central Delta via the Delta Cross Channel (DCC); (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and, (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.).

(3) *Water Conveyance and Flood Control*

The development of the water conveyance system in the Delta has resulted in the construction of more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995). Levee development in the Central Valley affects spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As Mount (1995) indicates, there is an “underlying, fundamental conflict inherent in this channelization.” Natural rivers strive to achieve dynamic equilibrium to handle a watersheds supply of discharge and sediment (Mount 1995). The construction of levees disrupts the natural processes of the river, resulting in a multitude of habitat-related effects.

Many of these levees use angular rock (riprap) to armor the bank from erosive forces. The effects of channelization, and riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006). These changes affect the quantity and quality of nearshore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000, Garland *et al*. 2002, Schmetterling *et al.* 2001). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

Prior to the 1970s, there was so much debris resulting from poor logging practices that many streams were completely clogged and were thought to have been total barriers to fish migration. As a result, in the 1960s and early 1970s it was common practice among fishery management agencies to remove woody debris thought to be a barrier to fish migration (NMFS 1996). However, it is now recognized that too much large woody debris was removed from the streams resulting in a loss of salmonid habitat and it is thought that the large scale removal of woody debris prior to 1980 had major, long-term negative effects on rearing habitats for salmonids in northern California (NMFS 1996). Areas that were subjected to this removal of large woody debris are still limited in the recovery of salmonid stocks; this limitation could be expected to persist for 50 to 100 years following removal of debris.

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996). Large woody debris influences channel morphology by affecting longitudinal profile, pool formation, channel pattern and position, and channel geometry. Downstream transport rates of sediment and organic matter are controlled in part by storage of this material behind large wood. Large wood affects the formation and distribution of habitat units, provides cover and complexity, and acts as a substrate for biological activity (NMFS 1996). Wood enters streams inhabited by salmonids either directly from adjacent riparian zones or from riparian zones in adjacent non-fish bearing tributaries. Removal of riparian vegetation and instream woody material (IWM) from the streambank results in the loss of a primary source of overhead and instream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project.

In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting salmonid food supply.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is a primary cause of salmonid habitat degradation (NMFS 1996). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity, and affecting inter-gravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival.

(4) ***Land Use Activities***

Land use activities such as agricultural conversion, and industrial and urban development continue to have large impacts on salmonid habitat in the Central Valley watershed, affecting spawning habitat, freshwater rearing habitat, freshwater migration corridors, estuarine areas, and nearshore marine area PCEs. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The CALFED Program (2000) estimated that wetter perimeter reductions in the Delta have decreased from between 25 and 45 percent since 1906. Historically, the San Francisco Estuary included more than 242,000 acres of tidally influenced bay-land habitats and tidal marsh and tidal flats accounted for 98 percent of bay-land habitats. Today only 70,000 acres of tidally influenced habitat remain (CALFED 2000). While historical uses of riparian areas (*e.g.*, wood cutting, clearing for agricultural uses) have substantially decreased, urbanization still poses a serious threat to remaining riparian areas. Riversides are desirable places to locate homes, businesses, and industry. Further, development within the floodplain results in vegetation removal, stream channelization, habitat instability, and point source (PS) and non-point source (NPS) pollution (NMFS 1996). The impacts of riparian vegetation and IWM loss are discussed in section (3) *Water Conveyance and Flood Control.*

In Pacific Northwest and California streams, habitat simplification has lead to a decrease in the diversity of anadromous salmonid species habitat (NMFS 1996). Habitat simplification may result from various land-use activities, including timber harvest, grazing, urbanization and agriculture. Reduction of wood in the stream channel, either from past or present activities, generally reduces pool quantity and quality, alters stream shading which can affect water temperature regimes and nutrient input, and can eliminate critical stream habitat needed for both vertebrate and invertebrate populations. Removal of vegetation also can destabilize marginally stable slopes by increasing the subsurface water load, lowering root strength, and altering water flow patterns in the slope. Constricting channels with culverts, bridge approaches, and streamside roads can reduce stream meandering, partially constrict or channelize flows, reduce pool maintenance, and can preclude passage of anadromous salmonids. Diverse habitats support diverse species assemblages and communities. This diversity contributes to sustained production and provides stability for the entire ecosystem. Further, habitat diversity can also mediate biotic interactions such as competition and predation. Attributes of habitat diversity include a variety and range of hydraulic parameters, abundance and size of wood, and variety of bed substrate (NMFS 1996).

PS and NPS pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e.* concrete) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for salmonid survival (NMFS 1996). In addition, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges.

Past mining activities routinely resulted in the removal of spawning gravels from streams, channelization of streams from dredging activities, and leaching of toxic effluents into streams. Many of the effects of past mining operations still impact salmonid habitat today. Current mining practices include suction dredging, placer mining, lode mining, and gravel mining. Present-day mining practices typically are less intrusive than historic operations (hydraulic mining); however, adverse impacts to salmonid habitat still occur as a result of present-day mining activities. Sand and gravel are used for a large variety of construction activities including base material and asphalt, road bedding, drain rock for leach fields, and aggregate mix for buildings and highways.

Most aggregate is derived principally from pits in active floodplains, pits in inactive river terrace deposits, or directly from the active channel. Other sources include hard rock quarries and mining from deposits within reservoirs. Extraction sites located along or in active floodplains present particular problems for anadromous salmonids. Physical alteration of the stream channel may result in the destruction of existing riparian vegetation and the reduction of available area for seedling establishment (Stillwater Sciences 2002). As discussed previously, loss of vegetation impacts riparian and aquatic habitat by causing a loss of the temperature moderating effects of shade and cover, and habitat diversity. Extensive degradation may induce a decline in the alluvial water table, as the banks are effectively drained to a lowered level, affecting riparian vegetation and water supply (NMFS 1996). Altering the natural channel configuration will reduce salmonid habitat diversity by creating a wide, shallow channel lacking in the pools and cover necessary for all life stages of anadromous salmonids. In addition, waste products resulting from past and present mining activities, include cyanide (an agent used to extract gold from ore), copper, zinc, cadmium, mercury, asbestos, nickel, chromium, and lead. These waste products have been found to be toxic to aquatic life, including fish.

(5) *Over Utilization*

Ocean Commercial and Sport Harvest: Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement. CWT returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI for Sacramento River winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of Sacramento River winter-run Chinook salmon. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). In 1996 and 1997, NMFS issued a biological opinion which concluded that incidental ocean harvest of Sacramento River winter-run Chinook salmon represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent. In 2001 the CVI dropped to 0.27, most likely due to the reduction in harvest and the higher abundance of other salmonids originating from the Central Valley (Good *et al*. 2005).

Ocean fisheries have affected the age structure of Central Valley spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). Ocean harvest rates of Central Valley spring-run Chinook salmon are thought to be a function of the CVI (Good *et al*. 2005). Harvest rates of Central Valley spring-run Chinook salmon ranged from 0.55 to nearly 0.80 between 1970 and 1995 when harvest rates were adjusted for the protection of Sacramento River winter-run Chinook salmon. The drop in the CVI in 2001 as a result of high fall-run escapement to 0.27 also reduced harvest of Central Valley spring-run Chinook salmon. There is essentially no ocean harvest of steelhead.

Inland Sport Harvest: Historically in California, almost half of the river sportfishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the City of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission (Commission) has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for Sacramento River winter-run Chinook salmon. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult Sacramento River winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures virtually have eliminated impacts on Sacramento River winter-run Chinook salmon caused by recreational angling in freshwater. In 1992, the Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run Chinook salmon caused by trout anglers. That same year, the Commission also adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken Central Valley spring-run Chinook salmon throughout the species' range. During the summer, holding adult Central Valley spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of Central Valley spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico creeks were added to the existing CDFG regulations in 1994. The current regulations, including those developed for Sacramento River winter-run Chinook salmon, provide some level of protection for spring-run fish (CDFG 1998).

There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams. Overall, this regulation has greatly increased protection of naturally-produced adult steelhead; however, the total number of Central Valley steelhead contacted might be a significant fraction of basin-wide escapement, and even low catch-and-release mortality may pose a problem for wild populations (Good *et al*. 2005).

(6) ***Disease and Predation***

Infectious disease is one of many factors that influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 1996, 1998). Specific diseases such as bacterial kidney disease, *Ceratomyxosis shasta* (C-shasta), columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect steelhead and Chinook salmon (NMFS 1996, 1998). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that native fish tend to be less susceptible to pathogens than hatchery reared fish. Salmonids may contract diseases that are spread through the water column (*i.e.*, waterborne pathogens) as well as through interbreeding with infected hatchery fish.

A fish may be infected yet not be in a clinical disease state with reduced performance. Salmonids typically are infected with several pathogens during their life cycle. However, high infection levels (number of organisms per host) and stressful conditions (crowding in hatchery raceways, release from a hatchery into a riverine environment, high and low water temperatures, *etc*.) usually characterize the system before a disease state occurs in the fish.

Accelerated predation also may be a factor in the decline of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, and to a lesser degree Central Valley steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson-Cottonwood Irrigation District's (ACID) diversion dam, GCID's diversion dam, areas where rock revetment has replaced natural river bank vegetation, and at south Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to factors such as water quality and flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall. In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters. Sacramento pikeminnow is a species native to the Sacramento River basin and has evolved with the anadromous salmonids in this system. However, rearing conditions in the Sacramento River today (*e.g.*, warm water, low-irregular flow, standing water, diversions) compared to its natural State and function 70 years ago, are more conducive to warm water species such as Sacramento squawfish and striped bass than native salmonids. Tucker *et al.* (1998) showed that predation during the summer months by Sacramento pikeminnow on juvenile salmonids jumped to 66 percent of total weight of stomach contents. Striped bass showed a strong preference for juvenile salmonids as prey during this study. This research also showed that the percent frequency of occurrence for juvenile salmonids and other fish were nearly equal in stomach contents. Tucker *et al.* (2003) showed the temporal distribution for these two predators in the RBDD area relative to the potential foraging impacts to juvenile salmonids. These researchers stated the importance of flow management to minimize the potential for condensing the concentration of forging areas.

USFWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997).

Predation on juvenile salmon has increased as a result of water development activities which have created ideal habitats for predators and non-native species (NIS). Turbulent conditions near dam bypasses, turbine outfalls, water conveyances, and spillways disorient juvenile steelhead migrants and increase their avoidance response time, thus improving predator success. Increased exposure to predators has also resulted from reduced water flow through reservoirs; a condition which has increased juvenile travel time. Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the Fish Facilities, and the Susuin Marsh Salinity Control Gates (SMSCG). Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Pickard *et al.* 1982), however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (NMFS 1997).

Although the behavior of salmon and steelhead reduces the potential for any single predator to focus exclusively on them, predation by certain species can be seasonally and locally significant. Changes in predator and prey populations along with changes in the environment, both related and unrelated to development, have been shown to reshape the role of predation (Li *et al.* 1987). Sacramento pikeminnow and striped bass, of the aquatic fish predators, have the greatest potential to negatively affect the abundance of juvenile salmonids. These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Catfish also have the potential to significantly affect the abundance of juvenile salmonids. Prickly (*Cottus asper*) and riffle (*C. gulosus*) sculpins, and larger salmonids also prey on juvenile salmonids (Hunter 1959; Patten 1962, 1971a, 1971b).

Avian predation on fish contributes to the loss of migrating juvenile salmonids by constraining natural and artificial production. Fish-eating birds that occur in the California Central Valley include great blue herons (*Ardea herodias*), gulls (*Larus spp*.), osprey (*Pandion haliaetus*), common mergansers (*Mergus merganser*), American white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax spp*.), Caspian terns (*Sterna caspia*), belted kingfishers (*Ceryle alcyon*), black-crowned night herons (*Nycticorax nycticorax*), Forster's terns (*Sterna forsteri*), hooded mergansers (*Lophodytes cucullatus*) and bald eagles (*Haliaeetus leucocephalus*) (Stephenson and Fast 2005). These birds have high metabolic rates and require large quantities of food relative to their body size.

Mammals may be an important agent of mortality to salmonids in the California Central Valley. Predators such as river otters (*Lutra Canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) are common. Other mammals that take salmonid include: badger (*Taxidea taxus*), bobcat (*Linx rufis*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), long-tailed weasel (*Mustela frenata*), mink (*Mustela vison*), mountain lion (*Felis concolor*), red fox (*Vulpes vulpes*), and ringtail (*Bassariscus astutus*). These animals, especially river otters, are capable of removing large numbers of salmon and trout (Dolloff 1993). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon. Pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Steller's sea lions (*Eumetopia jubatus*) are the primary marine mammals preying on salmonids (Spence *et al*. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) also prey on adult salmonids in the nearshore marine environment. Seal and sea lion predation is primarily in saltwater and estuarine environments, although they are known to travel well into freshwater after migrating fish. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable.

(7) *Climate Change*

The world is about 1.3 °F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may raise by two or more degrees in the 21st century (Intergovernmental Panel on Climate Change [IPCC] 2001). Much of that increase will likely occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Using objectively analyzed data Huang and Liu (2000) estimated a warming of about 0.9 °F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 m in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding and permanent inundation of low-lying natural ecosystems (*e.g*., salt marsh, riverine, mud flats) affecting salmonid PCEs. Increased winter precipitation, decreased snow pack, permafrost degradation and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions, and destroy fish and wildlife habitat, including salmon-spawning streams. Glacier reduction could affect the flow and temperature of rivers and streams that depend on glacier water, with negative impacts on fish populations and the habitat that supports them.

Summer droughts along the South Pacific coast and in the interior of the northwest Pacific coastlines will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to over take native fish species and impact predator-prey relationships (Stachowicz *et al.* 2002, Peterson and Kitchell 2001).

An alarming prediction is the fact that Sierra snow packs are expected to decrease with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains (CDWR 2006). This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold-water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, potentially could rise above thermal tolerances for juvenile and adult salmonids (*i.e.* Sacramento River winter-run Chinook salmon and Central Valley steelhead) that must hold below the dam over the summer and fall periods.

(8) ***Artificial Propagation***

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels. For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that early fall- and spring-run Chinook salmon were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. The FRH spring-run Chinook salmon have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run Chinook salmon, an indication that FRH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of Central Valley spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Hatchery and FRH, can directly impact spring-run Chinook salmon and steelhead populations by over saturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to hatchery overproduction and the inability to physically separate spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon often limits the amount if water available for steelhead spawning and rearing the rest of the year.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88 percent naturally produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37 percent naturally produced fish currently (Nobriga and Cadrett 2001). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001).

Hatcheries also can have some positive effects on salmonid populations. Artificial propagation has been shown to be effective in bolstering the numbers of naturally spawning fish in the short term under specific scenarios, artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally spawned populations at critically low abundance levels, as was the case with the Sacramento River winter-run Chinook salmon population during the 1990s. However, relative abundance is only one component of a viable salmonid population.

(9) *Ocean Conditions*

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al*. 1999). This phenomenon has been referred to as the Pacific Decadal Oscillation. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American West. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the West Coast.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival in the ocean is driven largely by events occurring between ocean entry and recruitment to a sub-adult life stage.

"El Niño" is an environmental condition often cited as a cause for the decline of West Coast salmonids (NMFS 1996). El Niño is an unusual warming of the Pacific Ocean off South America and is caused by atmospheric changes in the tropical Pacific Ocean (Southern Oscillation-ENSO). El Niño events occur when there is a decrease in the surface atmospheric pressure gradient from the normal-steady trade winds that blow across the ocean from east to west on both sides of the equator. There is a drop in pressure in the east off South America and a rise in the pressure in the western Pacific. The resulting decrease in the pressure gradient across the Pacific Ocean causes the easterly trade winds to relax, and even reverse in some years. When the trade winds weaken, sea level in the western Pacific Ocean drops, and a plume of warm sea water flows from west to east toward South America, eventually reaching the coast where it is reflected south and north along the continents.

El Niño ocean conditions are characterized by anomalous warm sea surface temperatures and changes coastal currents and upwelling. Principal ecosystem alterations include decreased primary and secondary productivity and changes in prey and predator species distributions.

(10) ***Floods and Droughts***

During flood events, land disturbances resulting from logging, road construction, mining, urbanization, livestock grazing, agriculture, fire, and other uses may contribute sediment directly to streams or exacerbate sedimentation from natural erosive processes (California Advisory Committee on Salmon and Steelhead Trout 1988, NMFS 1996). Sedimentation of stream beds has been implicated as a principle cause of declining salmonid populations through-out their range. In addition to problems associated with sedimentation, flooding can cause scour and redeposition of spawning gravels in typically inaccessible areas. As streams and pools fill in with sediment, flood flow capacity is reduced. Such changes cause decreased stream stability and increased bank erosion, and subsequently exacerbate existing sedimentation problems (NMFS 1996). All of these sources contribute to the sedimentation of spawning gravels and filling of pools and estuaries used by all anadromous salmonids. Channel widening and loss of pool-riffle sequence due to aggradation has damaged spawning and rearing habitat of all salmonids.

Unusual drought conditions may warrant additional consideration in California. Flows in 2001 were among the lowest flow conditions on record in the Central Valley. The available water in the Sacramento watershed and San Joaquin watershed was 70 percent and 66 percent of normal, according to the Sacramento River Index and the San Joaquin River Index, respectively. Back-to-back drought years could be catastrophic to small populations of listed salmonids that are dependent upon reservoir releases for their success (*e.g.*, Sacramento River winter-run Chinook salmon). Therefore, reservoir carryover storage (usually referred to as end-of-September storage) is a key element in providing adequate reserves to protect salmon and steelhead during extended drought periods. In order to buffer the effect of drought conditions and over allocation of resources, NMFS in the past has recommended that minimum carryover storage be maintained in Shasta and other reservoirs to help alleviate critical flow and temperature conditions in the fall.

(11) *Non-native Invasives*

The extensive introduction of NIS have dramatically altered the biological relationships between and among salmonids and the natural communities that share rivers (NMFS 1998). As currently seen in the San Francisco Estuary, NIS can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis*. The arrival of these clams in the estuary disrupted the normal benthic community structure and depressed phytoplankton levels in the estuary due to the highly efficient filter feeding of the introduced clams (Cohen and Moyle 2004). The decline in the levels of phytoplankton reduces the population levels of zooplankton that feed upon them, and hence reduces the forage base available to salmonids transiting the Delta and San Francisco Estuary which feed either upon the zooplankton directly or their mature forms. This lack of forage base can adversely impact the health and physiological condition of these salmonids as they emigrate through the Delta region to the Pacific Ocean.

Attempts to control the NIS also can adversely impact the health and well being of salmonids within the affected water systems. For example, the control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants to the probability of exposure to listed salmonids during herbicide application. In addition, the control of the nuisance plants has certain physical parameters that must be accounted for in the treatment protocols, particularly the decrease in DO resulting from the decomposing vegetable matter left by plants that have died.

(12) *Ecosystem Restoration*

Two programs included under CALFED; the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley. Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for Central Valley steelhead and spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CALFED-ERP have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Estuary in conjunction with tidal wetland restoration.

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward doubling the natural populations of select anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the Department of Interior's ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for Central Valley spring-run Chinook salmon and Central Valley steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

The U.S. Environmental Protection Agency's Iron Mountain Mine remediation involves the removal of toxic metals in acidic mine drainage from the Spring Creek Watershed with a State-of-the-art lime neutralization plant. Contaminant loading into the Sacramento River from Iron Mountain Mine has shown measurable reductions since the early 1990s. Decreasing the heavy metal contaminants that enter the Sacramento River should increase the survival of salmonid eggs and juveniles. However, during periods of heavy rainfall upstream of the Iron Mountain Mine, Reclamation substantially increases Sacramento River flows in order to dilute heavy metal contaminants being spilled from the Spring Creek debris dam. This rapid change in flows can cause juvenile salmonids to become stranded or isolated in side channels below Keswick Dam.

The CDWR's Four Pumps Agreement Program has approved approximately $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreements inception in 1986. Four Pumps projects that benefit Central Valley spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Estuary upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and, screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead.

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Estuary upstream into the Sacramento and San Joaquin River basins. These two enhanced enforcement programs have had significant benefits to spring-run Chinook salmon attributed to CDFG, but the results have not been quantified.

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District, CDFG, and CDWR allows CDWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cubic feet per second (cfs), only 12 cfs has been developed to date. In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek. In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. CDWR, CDFG, and USFWS have developed the Mill Creek Adaptive Management Enhancement Plan to address the instream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

2. Critical Habitat

According the NMFS CHART report (2005b) the major categories of habitat-related activities affecting Central Valley salmonids include: (1) irrigation impoundments and withdrawals (2) channel modifications and diking, (4) the presence and operation of hydroelectric dams, (5) flood control and streambank stabilization, and (6) exotic and invasive species introductions and management. All of these activities affect PCEs via their alteration of one or more of the following: stream hydrology, flow and water-level modification, fish passage, geomorphology and sediment transport, temperature, dissolved oxygen, nearshore and aquatic vegetation, soils and nutrients, physical habitat structure and complexity, forage, and predation (Spence *et al*. 1996, PFMC 1999). According to the NMFS CHART report (2005b), the condition of critical habitat varies throughout the range of the species. Generally, the conservation value of existing spawning habitat ranges from moderate to high quality, with the primary threats including changes to water quality, and spawning gravel composition from rural, suburban, and urban development, forestry, and road construction and maintenance. River and estuarine migration and rearing corridors range in condition from poor to high quality depending on location. Tributary migratory and rearing corridors tended to rate as moderate quality due to threats to adult and juvenile life stages from irrigation diversion, small dams, and water quality. Delta (*i.e.*, estuarine) and mainstem Sacramento and San Joaquin river reaches tend to rate poorly due to impaired hydrologic conditions from dam operations, water quality from agriculture, degraded nearshore and riparian habitat, and habitat loss and fragmentation. Although several Delta and mainstem river reaches were rated by the CHART report as poor quality, they were considered to have high conservation value because all or many of the listed populations use these areas for rearing and migration. These poor quality reaches also were determined to need special management considerations to ensure that they continue to function to support the survival and recovery of listed populations.

3. Southern Distinct Population Segment of North American Green Sturgeon

The principal factors for the decline in the Southern DPS of North American green sturgeon are reviewed in the proposed listing notice (70 FR 17386) and status reviews (Adams *et al*. 2002, NMFS 2005b), and primarily consist of: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) poor water quality; (3) over-utilization; (4) increased water temperatures; (5) NIS, and (6), other natural and manmade factors.

a. *The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range*

(1) *Habitat Blockage and Range*

NMFS (2005) evaluated the ability to rank threats, but concluded that this was not possible due to the lack of information about their impact on the Southern DPS of North American green sturgeon; however, the principle threat considered is the impassible barriers, primarily Keswick and Shasta Dams on the Sacramento River and Feather River that likely block and prevent access to historic spawning habitat (NMFS 2005a). Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning suggests that significant potential green sturgeon spawning habitat was made inaccessible or altered by dams (historical habitat characteristics, temperature, and geology summarized by Lindley *et al*. (2006b). This spawning habitat may have extended up into the three major branches of the Sacramento River; the Little Sacramento River, the Pitt River system, and the McCloud River (NMFS 2005a). In contrast, recent modeling evaluations by Mora (2006) indicate little or no habitat in the little Sacramento River or the Pit River exists above Shasta dam; however, a considerable amount of habitat exists above Shasta on the mainstem Sacramento River. Green and white sturgeon adults have been observed periodically in the Feather and Yuba River (USFWS 1995, Beamesderfer *et al*. 2004, Jeff McLain, NMFS, pers. comm., 2006) and habitat modeling my Mora (2006) suggests there is sufficient habitat above Oroville Dam. There are no records of larval or juvenile white or green sturgeon; however, there are reports that green sturgeon may reproduce in the Feather River during high flow years (CDFG 2002), but these are unconfirmed. No green sturgeon have been observed in the San Joaquin River; however, the presence of white sturgeon has been documented (USFWS 1995, Beamesderfer *et al*. 2004) making the presence of green sturgeon likely historically as the two species require similar habitat and their ranges overlap in the Sacramento River. Habitat modeling by Mora (2006) also suggests sufficient conditions are present in the San Joaquin River to Friant Dam, and in the Stanislaus, Tuolumne, and Merced rivers to the dams. In addition, the San Joaquin River had the largest spring-run Chinook salmon population in the Central Valley prior to the construction of Friant Dam (Yoshiyama *et al*. 2001) with escapements approaching 500,000 fish. Thus it is very possible, based on prior spring-run Chinook salmon distribution and habitat use of the San Joaquin River, that green sturgeon were extirpated from the San Joaquin basin in a similar manner to spring-run. The loss of potential green sturgeon spawning habitat on the San Joaquin River also may have contributed to the overall decline of the Southern DPS of North American green sturgeon.

(2) ***Water Diversion***

Based on the limited information regarding the size of green sturgeon larvae and nocturnal behavior during their development as well as the high number of diversions on the Sacramento River, it is reasonable to assume the potential threats of water diversions to green sturgeon are relatively high. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al*. 2001). After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). At 5 days of age, larvae are approximately 22 mm in total length (Van Eenennaam *et al*. 2001). Based on this information, it is assumed larvae green sturgeon are suseptable to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal behavior (starting at day 6), and at a total length of approximatley 22 mm.

Herren and Kawasaki (2001) documented up to 431 diversions in the Sacramento River between Sacramento and Shasta Dam, most of which were unscreened and of the vertical or slant pump type. Entrainment information regarding larval and post-larval Southern DPS of North American green sturgeon is paltry, as the field identification of green sturgeon larvae is difficult. USFWS staff are working on identification techniques and are optimistic that green sturgeon greater than 40 mm can be identified in the field (Bill Poytress, USFWS, pers. comm. 2006). Captures reported by GCID are not identified to species but are asummed to primarily consist of green sturgeon as white sturgeon are known to spawn primarily between Knights Landing and Colusa (Schaffter 1997). Screens at GCID satisfy both the NMFS and CDFG screening criteria; however, the effectiveness of NMFS and CDFG screen criteria is unknown for sturgeon and there is a possibility that larval and post-larval green sturgeon are taken at GCID. Low numbers of Southern DPS of North American green sturgeon have also been identified and entrained at the Red Bluff Research Pumping Plant (Borthwick *et al*. 1999) and the efficacy of identification and enumeration of entrained post-larval green sturgeon is unknown at this location. The ACID diversion facility also may threaten larval and post-larval Southern DPS of North American green sturgeon as the upstream location of this facility exposes larvae and post-larval stages to entrainment. Information on the entrainment and impacts of this diversion on Southern DPS North American green sturgeon are unknown. Information regarding the impacts of other small scale diversion indicated in Herren and Kawaski (2001) in the Sacramento River is unknown.

Presumably, as green sturegon juveniles grow, they become less suseptable to entrainment as their capacity to excape diversions improve. The majority of Southern DPS North American green sturgeon captured in the Delta and San Francisco Estuary are between 200 and 500 mm (CDFG 2002). Herren and Kawasaki (2001) inventoried water diversions in the Delta finding a total of 2,209 diversions of various types, only 0.7 percent of which were screened. The majority of these diversions were between 12 and 24 inches in diameter, likely with relatively little threat to larger juvenile sturgeon. The largest diversions recorded were those of the Fish Facilities in the south Delta. Based on historical data and captures at the Fish Facilities (CDFG 2002), it is reasonable to assume an unknown portion of the juvenile and adult population is excessively stressed, injured, harassed, or killed by the pumping plants.

Eight large diversions greater than 10 cfs and approximately 60 small diversions between 1-10 cfs exist on the Feather River between the Thermalito Afterbay outlet and the confluence with the Sacramento River (USFWS 1995). No studies to date have specifically addressed sturgeon entrainment on the Feather River; however, studies related to Chinook salmon entrainment at the Sutter Extension Water District's sunrise pumps found significant losses of juvenile salmon (USFWS 1995). Based on potential entrainment problems of green sturgeon elsewhere in the Central Valley and the presence of multiple screened and unscreened diversions in the Feather River, it is assumed that water diversions on the Feather River are a possible threat to juvenile Southern DPS North American green sturgeon.

A significant number of studies have been completed indicating that water exports are a limiting factor on native fish in the Delta (Kjelson *et al*. 1981, Kjelson *et al*. 1990, Meng *et al*. 1994, Meng and Moyle 1995, Arthur *et al*. 1996, Bennett and Moyle 1996, Meng and Matern 2001). CDFG (1992) found a strong correlation between mean daily freshwater outflow (April to July) and white sturgeon year class strength in the Delta (many of the studies concerning sturgeon in the Delta involve the more abundant white sturgeon; however, the threats to green sturgeon are thought to be similar). Additional evidence supporting this relationship was also found when comparing annual production of young sturgeon in the San Francisco Estuary and salvage of young sturgeon at the Skinner Fish Facility between 1968 and 1987 during the months of April and May (CDFG 1992). This association of year class strength with outflow is also found in other anadromous fishes inhabiting the Estuary, such as striped bass, Chinook salmon, American shad, and longfin smelt (Stevens and Miller 1983). It is postulated that these increased outflows could improve survival by transporting dispersing larvae to areas of greater food availability, by dispersing larvae over a wide area of the rivers and San Francisco Estuary to take advantage of all available habitat, by quickly moving larvae downstream of any influence of water diversions in the Delta, or by enhancing productivity in the nursery area by increasing nutrient supply (CDFG 1992). Because of the young-of-year (YOY) flow correlation in the Delta exists, it is also assumed to be a factor in tributary flows.

In an effort to quantify the flow requirements necessary to double sturgeon populations on the Sacramento River, USFWS (1995) used the YOY year class estimates and corresponding flow data on the Sacramento River to identify years with good recruitment of white sturgeon. Year class estimates greater than two times the mean year class estimates were classified as good recruitment years. All other years were classified as poor recruitment years. Flow measured in the Sacramento River at Grimes and at Verona between February 1 and May 31 was then compared with corresponding YOY year class estimates between 1968 and 1990. All good recruitment years occurred in both wet or above-normal years and the flow from the good recruitment year with the lowest flow was used as a minimum flow standard (USFWS 1995). A minimum flow of 17,700 cfs between February 1 and May 31 at Grimes (RM 125) on the

Sacramento River for wet and above normal water year types was recommended to provide adequate flows to allow adult migration from the San Francisco Estuary or ocean to spawning grounds, spawning, and downstream larval transport (USFWS 1995). Flows at or above 17,700 cfs occurred six times or 26 percent of the time. This flow was not reached during the six years between 1999 and 2004, though the 1999 and 2000 water years were close at 17,054 and 17,154 cfs respectively. Until additional instream flow studies relating to sturgeon are complete, these flow recommendations offer an approximate target. Additional flow recommendations as measured at Verona on the Sacramento River (RM 80) are also provided in USFWS 1995.

No specific studies of the effects of water diversions on the Southern DPS of North American green sturgeon have been completed to date; however, based on the considerable amount of evidence regarding the effects of diversions on other native fish, including white sturgeon, it is likely that water diversions also impact the Southern DPS of North American green sturgeon.

(3) ***Water Conveyance***

The impacts of the development of the water conveyance system in the Central Valley have been reviewed in section C: *Factors Affecting the Species and Critical Habitat, Chinook Salmon and Central Valley Steelhead* of this biological option. As mentioned previously, the impacts of channelizing and bank riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006), as well as can adversely affect important ecosystem functions. In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting secondary consumer food supply (fish). Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile fish. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. Information on the lateral dispersion of green sturgeon across channel profiles is limited. Based on the benthic orientation of green sturgeon it is assumed habitat related impacts of channelization and riprapping would primarily consist of ecosystem related impacts, such as food source changes, and altered predator densities. The impacts of channelization and riprapping are though to affect larval, post-larval, juvenile and adult stages of Southern DPS North American green sturgeon, as they are all dependant upon the food web in freshwater for at least a portion of their life cycle.

(4) ***Migration Barriers***

Adult migration barriers to green sturgeon include structures such as the RBDD, ACID, Sacramento Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and DCC Gates. Major physical barriers to adult sturgeon migration on the mainstem Sacramento River are the RBDD and ACID diversion dam (USWFS 1995). Unimpeded migration past RBDD occurs when gates are raised between mid September and May for winter-run Chinook salmon passage measures. Fish ladders at RBDD are designed for salmonid passage and are used when dam gates are raised; however, improvements to the fish ladders may be possible if they can be designed to emulate the north ladder on Bonneville Dam on the Columbia River, which passes sturgeon successfully (CDFG 2002). Tagging studies by Heublein *et al.* (2006) found a substantial portion of tagged adults failed to pass RBDD prior to May 15 and thus were unable to access spawning habitat upstream. The fate of the blocked green sturgeon is unknown. The Sacramento River Deep Water Ship Channel connects with the Sacramento River near the Cache Slough confluence above Rio Vista and provides a deepened and straightened channel to West Sacramento for commercial shipping purposes. A set of locks at the end of the channel at the connection with Sacramento River (in West Sacramento) "blocks the migration of all fish from the deep water ship channel back to the Sacramento River" (CDWR 2003).

Fremont Weir is located at the end of Yolo Bypass, a 40-mile long basin that functions as a flood control outlet. CDWR (2003) indicates that "sturgeon and sometimes salmon are attracted by high flows into the Yolo Bypass basin and then become concentrated behind Fremont Weir." They are then subject to heavy legal and illegal fishing pressure. In addition, field and anecdotal evidence shows that adult green sturgeon migrate up the Yolo Bypass up the Toe Drain in autumn and winter regardless of Fremont Weir spills (CDWR 2003). The weir is approximately 90 feet long and 5 feet high containing a poorly functioning fish ladder.

Numerous weirs and barriers in the Sutter Bypass known to be passage issues for Chinook salmon also could block sturgeon migration. Sturgeon are attracted to discharges into the toe drains of the Yolo Bypass and subsequently can't re-enter the Sacramento River. In addition, sturgeon attempt to pass over the Freemont weir during flood flows and become stranded behind the flashboards when the flows recede. Though most of these barriers have fish passage structures that work during certain flows (CDWR 2003), they are mostly designed for salmonid passage and would likely block sturgeon.

Upstream migrating adult Chinook salmon are known to utilize the DCC as a migratory pathway (Hallock *et al*. 1970). When the gates are open, Sacramento River water flows into the Mokelumne and San Joaquin Rivers providing migration cues. Attraction to this diverted water is thought to be one of the factors delaying and increasing the straying rate of Chinook salmon (CALFED Science Program 2001, McLaughlin and McLain 2004). In addition to increased travel distances, gate closures can completely block anadromous fish migrations forcing the fish to hold or retrace their routes through the Delta to reach spawning grounds upstream. DCC gate closures typically occur during the winter and early spring months when sturgeon are believed to migrate. Evidence suggests that female sturgeon reabsorb eggs and forgo spawning if prevented from reaching spawning grounds (USFWS 1995). In addition, potential spawning habitat is blocked. Habitat between RBDD and Jelly's Ferry Bridge (RM 267) contains swift current and pools over 20 feet deep as well as contains sand to sand-gravel mixtures found to be preferred by spawning white sturgeon (USFWS 1995, Schaffter 1997, CDFG 2002). Significant evidence exists that green sturgeon prefer similar spawning habitat, yet spawn above white sturgeon spawning areas on the Sacramento River (CDFG 2002).

Exact sturgeon spawning locations in Feather River are unknown; however, based on angler catches, most spawning is believed to occur downstream of Thermalito Afterbay and upstream of Cox's Spillway, just downstream of Gridley Bridge (USFWS 1995). The upstream migration barrier is likely a steep riffle 1 mile upstream of the Afterbay outlet with a depth of approximately 6 inches and length of 394 feet. Potential physical barriers to upstream migration include the rock dam associated with Sutter Extension Water District's sunrise pumps, shallow water caused by a head cut at Shanghai Bend, and several shallow riffles between the confluence of Honcut Creek upstream to the Thermalito Afterbay outlet (USFWS 1995). These structures are likely to present barriers to sturgeon during low flows blocking and or delaying migration to spawning habitat.

(5) ***Poor Water Quality***

PS and NPS pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e*. concrete) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for steelhead survival (NMFS 1996).

Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates of green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995). Principle sources of organic contamination in the Sacramento River are rice field discharges from Butte Slough, Reclamation District 108, Colusa Basin Drain, Sacramento Slough, and Jack Slough (USFWS 1995). Discharge of rice irrigation water has caused mortality to both *Ceriodaphnia* and fathead minnows in the Sacramento River and it is believed that rice field discharges in May and June could affect sturgeon larvae survival (USFWS 1995). No specific information is available on contaminant loads or impacts to green sturgeon, however, the difference in distribution of green and white sturgeon (ocean migrants vs. estuarine inhabitants) probably makes green sturgeon less vulnerable than white sturgeon to bioaccumulation of contaminants found in the estuary (CDFG 2002).

High levels of trace elements can also decrease sturgeon early life-stage survival, causing abnormal development and high mortality in yolk-sac fry sturgeon at concentrations at the levels of parts per billion (Dettlaff *et al.* 1981, as referenced in USFWS 1995). Water discharges from Iron Mountain Mine have affected survival of fish downstream of Keswick Dam and storage limitations and limited availability of dilution flows cause downstream copper and zinc levels to exceed salmonid tolerances (USFWS 1995). Although the impact of trace elements on Southern

DPS of North American green sturgeon production is not completely understood, negative impacts are suspected (USFWS 1995).

Organic contaminants from agricultural returns, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Feather River (USFWS 1995). Feather River water collected at Verona on May 27 and June 5, 1987, resulted in a 50 and 60 percent mortality in *Ceriodaphnia* and fathead minnow bioassays, respectively. Similar effects were also found in the Feather River in 1988 and 1989 (Regional Board, 1991, as cited in USFWS 1995). Toxic effects were attributed to organic contaminants in rice irrigation water released into Jack Slough and into Honcut Creek and Bear River to a lesser degree. Elevated levels of arsenic, chromium, copper, and mercury exceeding median international standards were found in various fish species in the Feather River between 1978 and 1987.

Water quality in the San Joaquin River has degraded significantly since the late 1940s (Regional Board 2004). During this period, salt concentrations in the River, near Vernalis, have doubled. Concentrations of boron, selenium, molybdenum, and other trace elements have also increased (Regional Board 2004). The extent of this problem as it relates to green sturgeon viability is unknown; however, it is clear that water quality on the San Joaquin River is potentially a problem for sturgeon (USFWS 1995). Doroshov (2006) indicated that green sturgeon primarily consume clams containing high levels of selenium in the Estuary. The selenium is then transferred to the egg yolk where it causes mortalities of larvae.

(6) *Over Utilization and Poaching*

Commercial harvest for green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries (Jeff McLain, NMFS, pers. comm., 2006). Green sturgeon also have been incidentally captured in the California set-net fishery, in southern California. Adams *et al*. (2002) reported harvest of green sturgeon from California, Oregon, and Washington between 1985 and 2001. Total captures of green sturgeon in the Columbia River Estuary by commercial means ranged from 240 fish per year to 6,000. Catches in Willapa Bay and Grays Harbor by commercial means combined ranged from 9 fish to 2,494 fish per year. Emmett *et al*. (1991) indicated that an average of 4.7 to 15.9 tons of green sturgeon were landed annually in Grays Harbor and Willapa Bay respectively. Overall, captures appear to be dropping through the years; however, this could be related to changing fishing regulations. Adams *et al*. (2002) also reported sport fishing captures in California, Oregon, and Washington. Within the San Francisco Estuary, green sturgeon are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun bays (Emmett *et al*. 1991). While no sport fishing captures can be attributed to California as all green sturgeon captured are captured incidentally, sport fishing in the Columbia River, Willapa Bay, and Grays Harbor captured from 22 to 553 fish per year between 1985 and 2001. Again, it appears sport fishing captures are dropping through time; however, it is not known if this is a result of abundance, changed fishing regulations, or other factors. Based on new research by Israel (2006a) and past tagged fish returns reported by CDFG (2002), a high proportion of green sturgeon present in the

Columbia River, Willapa Bay, and Grays Harbor (as much as 80 percent in the Columbia River) may be Southern DPS North American green sturgeon. This indicates a potential threat to the Southern DPS North American green sturgeon population.

Due to slot limits imposed on the sport fishery by the CDFG, only white sturgeon between 46 and 72 inches may be retained by sport fisherman with a daily bag limit of 1 fish in possession. Currently under emergency fishing regulations, all green sturgeon are to be returned to the water. CDFG (2002) indicates high sturgeon vulnerability to the fishery in areas where sturgeon are concentrated, such as the Delta to San Pablo Bay area in late winter and the upper Sacramento River during the spawning migration. In addition, the trophy status of white sturgeon and the consequent incentive for retaining oversize (>183 cm) fish is another impetus for active enforcement of sturgeon angling regulations (CDFG 2002).

Poaching rates on the Feather River are unknown; however, catches of sturgeon occur during all years, especially during wet years. There is no catch, effort, and stock size data precluding exploitation estimates (USFWS 1995). Areas just downstream of Thermalito Afterbay outlet and Cox's Spillway, and several barriers impeding migration may be areas of high adult mortality from increased fishing effort and poaching.

Poaching rates on the San Joaquin River are unknown; however, catches of sturgeon occur during all years, especially during wet years. There is no catch, effort, and stock size data precluding exploitation estimates. What is known, is that the small population of sturgeon inhabiting the San Joaquin River experiences heavy fishing pressure, particularly regarding illegal snagging and it may be more than the population can support (USFWS 1995).

(7) *Increased Water Temperature*

Water temperatures greater than 63 ºF can increase sturgeon egg and larval mortality (Pacific States Marine Fisheries Commission 1992). Temperatures near RBDD on the Sacramento River historically occur within optimum ranges for sturgeon reproduction; however, temperatures downstream of RBDD, especially later in the spawning season, were reported to be frequently above 63 ºF (USFWS 1995). High temperatures in the Sacramento River during the February to June period no longer appear to be a concern as temperatures in the upper Sacramento River are actively managed for Sacramento River winter-run Chinook salmon, and the Shasta temperature curtain device installed at Shasta Dam in 1997 appears to maintain cool water conditions. A review of temperatures at RBDD during May and June between the years of 1995 and 2004 found no daily temperatures greater than 60 ºF (California Data Exchange Center preliminary data, RBDD daily water temperature data).

Approximately 5 miles downstream of Oroville Dam, water is diverted at the Thermalito Diversion Dam, into the Thermalito Power Canal, thence to the Thermalito Forebay and another powerhouse and finally into the Thermalito Afterbay. The Oroville-Thermalito Complex provides water conservation, hydroelectric power, recreation, flood control, and fisheries benefits. Feather River flows downstream of Oroville Dam to the Thermalito Diversion Dam is often referred to as the "low-flow" river section and maintains a constant 600 cfs. Thus, water temperatures downstream of the Thermalito Afterbay outlet are considerably higher than temperatures in the low-flow channel (USFWS 1995). It is likely that high water temperatures (greater than 63 ºF) may deleteriously affect sturgeon egg and larval development, especially for late-spawning fish in drier water years (USFWS 1995). CDFG (2002) also indicated water temperatures may be inadequate for spawning and egg incubation in the Feather River during many years as the result of releases of warmed water from Thermalito Afterbay. They believed that this may be one reason neither green nor white sturgeon are found in the river in low-flow years. It is not expected that water temperatures will become more favorable in the near future (CDFG 2002) and this temperature problem will continue to be a threat.

The lack of flow in the San Joaquin River as a result of Friant Dam operations and agricultural return flows also contributes to higher temperatures in the mainstem San Joaquin River offering less water to keep temperatures cool for anadromous fish. Temperatures directly affect survival, growth rates, distribution, and development rates of anadromous fish. In addition, temperatures indirectly affect growth rate, distribution, and development rate of anadromous fish (Myrick and Cech 2004). Though these effects are difficult to measure, temperatures in the lower San Joaquin River continually exceed preferred temperatures for sturgeon migration and development during spring months. Optimal temperatures for egg and larval survival of white sturgeon are between 50 and 63 ºF and survival at early-developmental stages is severely reduced at temperatures greater than 68 ºF (USFWS 1995). CDFG indicates water temperatures during May when Vernalis flow is less than 5,000 cfs were at levels causing chronic stress in juvenile Chinook salmon (Reynolds *et al*. 1993). Temperatures at Stevenson on the San Joaquin River near Merced River confluence on May 31 between 2000 and 2004 ranged from 77.2 to 81.7 ºF (California Data Exchange Center, preliminary data). Juvenile sturgeon are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. High water temperatures on the San Joaquin River and in the Delta are likely a threat to the Southern DPS of North American green sturgeon.

(8) ***Non-native Invasives***

Green sturgeon have most likely been impacted by NIS introductions resulting in changes in trophic interactions in the Delta. Many of the recent introductions of invertebrates have greatly affected the benthic fauna in the Delta and bays. CDFG (2002) reviewed many of the recent NIS introductions and the potential consequences to green sturgeon. Most notable species responsible for altering the trophic system of the Sacramento-San Joaquin Estuary include the overbite clam, the Chinese mitten crab, the introduced mysid shrimp (*Acanthomysis bowmani)*, and another introduced isopod (*Gammarus* sp). Likewise, introductions of invasive plant species such as the water hyacinth (*Eichhornia crassipes*) and *Egeria densa* have altered nearshore and shallow water habitat by raising temperatures and inhibiting access to shallow water habitat. *Egeria densa* forms thick “walls” along the margins of channels in the Delta. This growth prevents juvenile native fish from accessing their preferred shallow water habitat along the channel’s edge. Water hyacinth creates dense floating mats that can impede river flows and alter the aquatic environment beneath the mats. DO levels beneath the mats often drop below sustainable levels for fish due to the increased amount of decaying vegetative matter produced from the overlying mat. Like *Egeria*, water hyacinth is often associated with the margins of the Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions permit. This level of infestation can produce barriers to anadromous fish migrations within the Delta. The introduction and spread of *Egeria* and water hyacinth have created the need for aquatic weed control programs that utilize herbicides targeting these species. The effects of these herbicides on green sturgeon are similar to salmon, and include bioaccumulation, and mortality to eggs and larvae.

(9) *Dredging*

Hydraulic dredging is a common practice in the Delta and San Francisco Estuary to allow commercial and recreational vessel traffic. Such dredging operations use a cutterhead dredge pulling water upwards through intake pipelines, past hydraulic pumps, and down outflow pipelines to disposal sites placing bottom oriented fish such as North American green sturgeon at risk. Studies by Buell (1992) reported approximately 2,000 sturgeon entrained in the removal of one million tons of sand from the bottom of the Columbia River at depths of 60-80 feet. In addition, dredging operations can elevate toxics such as ammonia, hydrogen sulfide, and copper (NMFS 2006). Other factors include bathymetry changes and acoustic impacts (NMFS 2006).

(10) *Climate Change*

The potential effects of climate change on the listed salmonids were discussed in the *Chinook Salmon and Central Valley Steelhead* section and primarily consist of altered ocean temperatures and stream flow patterns in the Central Valley. Changes in Pacific Ocean temperatures can alter predator prey relationships and affect migratory habitat of the Southern DPS of North American green sturgeon. Increases in rainfall and decreases in snow pack in the Sierra Nevada range will affect cold-water pool storage in reservoirs affecting river temperatures. As a result, the quantity and quality of water that may be available to the Southern DPS of North American green sturgeon will likely significantly decrease.

(11) *Conservation Measures*

The AFRP specifically applies the doubling effort toward Chinook salmon, Central Valley steelhead, striped bass, and white and green sturgeon. Though most efforts of the AFRP have primarily focused on Chinook salmon as a result of their listing history and status, the Southern DPS of North American green sturgeon may receive some unknown amount of benefit from these restoration efforts. For example, the acquisition of water for flow enhancement on tributaries to the Sacramento River, fish screening for the protection of Chinook salmon and Central Valley steelhead, or riparian revegetation and instream restoration projects would likely have some ancillary benefits to the Southern DPS. The AFRP has also invested in one green sturgeon research project that has helped improve our understanding of the life history requirements and temporal patterns of the of the Southern DPS of North American green sturgeon.

Many notable beneficial actions have originated and been funded by the CALFED program including such projects as floodplain and instream restoration, riparian habitat protection, fish screening and passage projects, research regarding NIS and contaminants, restoration methods, and watershed stewardship and education and outreach programs. Prior Federal Register notices have reviewed the details of CVPIA and CALFED programs and potential benefits towards anadromous fish, particularly Chinook salmon and Central Valley steelhead (50 CFR 33102). Projects potentially benefiting North American green sturgeon primarily consist of fish screen evaluation and construction projects, restoration evaluation and enhancement activities, contaminations studies, and DO investigations related to the San Joaquin River Deep Water Ship Channel. Two evaluation projects specifically addressed green sturgeon while the remaining projects primarily address listed salmonids and fishes of the area in general. The new information from research will be used to enhance our understanding of the risk factors affecting recovery thereby improving our ability to develop effective management measures.

IV. ENVIRONMENTAL BASELINE

The environmental baseline "includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR §402.02).

A. Status of the Species and Critical Habitat in the Action Area

1. <u>Status of the Species Within the Action Area</u>

The action area functions as a migratory corridor for adult Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead, and provides migration and rearing habitat for juveniles of these species. A large proportion of all Federally listed Central Valley salmonids are expected to utilize aquatic habitat within the action area. The action area also functions as a migratory and holding corridor for adult and rearing and migratory habitat for juvenile Southern DPS of North American green sturgeon.

a. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon are currently only present in the Sacramento River below Keswick Dam, and are composed of a single breeding population (*Status of the Species and Critical Habitat* section). The entire population of migrating adults and emigrating juveniles must pass through the action area.

A detailed assessment of the migration timing of Sacramento River winter-run Chinook salmon was reviewed in the *Status of the Species and Critical Habitat* section. Adult Sacramento River winter-run Chinook salmon are expected to be present in the Sacramento River portion of the action area between November and June (Myers *et al*. 1998, Good *et al*. 2005) as they migrate to spawning grounds. Juvenile Sacramento River winter-run Chinook salmon migration patterns in the Sacramento River and Steamboat Slough can best be described by temporal migration characteristics found by the USFWS (2001) in beach seine captures along the lower Sacramento River between Sacramento and Princeton, and in the Delta south of Sacramento along the Sacramento River, and in nearby channels such as Steamboat and Georgiana sloughs. Because beach seining samples the shoreline rather than the center of the channel as is often the case in rotary screw traps and trawls, it is considered the most accurate sampling effort in predicting the nearshore presence of juvenile salmonids. In the Sacramento River, between Princeton and Sacramento, juveniles are expected between September and mid April, with highest densities between December and March (USFWS 2001). Delta captures were similar, but slightly later as they are downstream; juveniles are expected between November and mid April with highest densities between December and February. Rotary screw trap work at Knights Landing on the Sacramento River by Snider and Titus (2000) captured juveniles between August and April, with heaviest densities observed first during November and December, and second during January through March. The presence of juvenile Sacramento River winter-run Chinook salmon in Steamboat slough is dependant on hydrologic conditions and the species exposure to them in the north Delta (Jeff McLain, NMFS, pers. comm., 2006). For example, the operation of the DCC gates affects Sacramento River flow entering Steamboat Slough increasing salmonid diversions into Steamboat Slough. In most cases, past catches of Sacramento River winter-run Chinook salmon juveniles in Steamboat sloughs have been relatively low (Jeff McLain, NMFS, pers. comm., 2006

b. *Central Valley Spring-run Chinook Salmon*

CV spring-run Chinook salmon populations currently spawn in the Sacramento River below Keswick Dam, the low-flow channel of the Feather River, and in Sacramento River tributaries including Mill, Deer, Antelope, and Butte Creeks (CDFG 1998). The entire population of migrating adults and emigrating juveniles must pass through the action area.

A detailed assessment of the migration timing of CV spring-run Chinook salmon was reviewed in the *Status of the Species and Critical Habitat* section. Adult CV spring-run Chinook salmon are expected on the Sacramento River between March and July (Myers *et al*. 1998, Good *et al*. 2005). Peak presence is believed to be during February and March (CDFG 1998). In the Sacramento River, juveniles may begin migrating downstream almost immediately following emergence from the gravel with most emigration occurring from December through March (Moyle *et. al.* 1989, Vogel and Marine 1991). Snider and Titus (2000) observed that up to 69 percent of spring-run Chinook salmon emigrate during the first migration phase between November and early January. The remainder of the CV spring-run Chinook salmon emigrate during subsequent phases that extend into early June. The age structure of emigrating juveniles is comprised of YOY and yearlings. The exact composition of the age structure is not known, although populations from Mill and Deer Creek primarily emigrate as yearlings (Colleen Harvey-Arrison, CDFG, pers. comm., 2004), and populations from Butte Creek primarily emigrate as fry (Ward *et. al.* 2002). Younger juveniles are found closer to the shoreline than older individuals (Healey 1991). As is the case for Sacramento River winter-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon in Steamboat slough is dependant on hydrologic conditions and the species exposure to them in the north Delta (Jeff McLain, NMFS, pers. comm., 2006). In most cases, past catches of CV spring-run Chinook salmon juveniles in Steamboat slough have been relatively low (Jeff McLain, NMFS, pers. comm., 2006).

c. *Central Valley Steelhead*

CV steelhead populations currently spawn in tributaries to the Sacramento and San Joaquin Rivers. The proportion of steelhead in this DPS that migrate through the action area is unknown. However, because of the relatively large amount of suitable habitat in the Sacramento River relative to the San Joaquin River, it is probably high. Adult steelhead may be present in all parts of the action area from June through March, with the peak occurring between August and October (Bailey 1954, Hallock *et al.* 1957). Highest abundance of adults and juveniles is expected in the Sacramento River part of the action area. Juvenile steelhead emigrate through the Sacramento River from late fall to spring. Snider and Titus (2000) observed that juvenile steelhead emigration primarily occurs between November and May at Knights Landing. The majority of juvenile steelhead emigrate as yearlings and are assumed to be primarily utilizing the center of the channel rather than the shoreline.

d. *Southern DPS of North American Green Sturgeon*

The spawning population of the Southern DPS of North American green sturgeon is currently restricted to the Sacramento River below Keswick Dam, and is composed of a single breeding population (*Status of the Species and Critical Habitat* section), thus the entire population of adults and juveniles must pass through the action area.

A detailed assessment of the migration timing and life-history of the Southern DPS of North American green sturgeon was reviewed in the *Status of the Species and Critical Habitat* section. Adult Southern DPS of North American green sturgeon migrate upstream through the action area primarily between March and June (Adams *et al*. 2002). Larva and post-larvae are present on the lower Sacramento River between May and October, primarily during June and July (CDFG 2002). Small numbers of juvenile Southern DPS of North American green sturgeon have been captured at various locations on the Sacramento River as well in the Delta (in the action area downstream of Sacramento) during all months of the year (IEP Database, Borthwick *et al*. 1999).

2. Status of Critical Habitat Within the Action Area

a. *Sacramento River winter-run Chinook salmon, Central Valley Steelhead and Central Valley spring-run Chinook Salmon*

The action area is within designated critical habitat for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. Habitat requirements for these species are similar. The PCEs of salmonid habitat within the action area include: freshwater rearing habitat, freshwater migration corridors, and estuarine areas, containing adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food; riparian vegetation, space, and safe passage conditions. Habitat within the action area is primarily used as freshwater rearing and migration and as freshwater migration for adults. The condition and function of this habitat has been severely impaired through several factors discussed in the *Status of the Species and Habitat* section of this biological opinion. The result has been the reduction in quantity and quality of several essential elements of migration and rearing habitat required by juveniles to grow, and survive. In spite of the degraded condition of this habitat, the conservation value of the action area is high because its entire length is used for extended periods of time by a large proportion of all Federally listed anadromous fish species in the Central Valley.

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids have evolved. Changes in streamflows and diversions of water affect freshwater rearing habitat and freshwater migration corridor PCEs in the action area. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (California Regional Water Quality Control Board-Central Valley Region 1998) that contaminate drainage waters and destroy aquatic life necessary for salmonid survival (NMFS 1996). In addition, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges in the action area. Accelerated predation as a result of habitat changes in the action area, such as the alteration of natural flow regimes and the installation of bank revetment structures such as dams, bridges, water diversions, and piers are likely a factor in the decline of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead.

Within the action area, the freshwater rearing and migration PCEs have been transformed from a meandering waterway lined with a dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes and flooding. In the reach from Colusa downstream to Verona (RMs 143 to 80) levees are generally constructed near the edge of the river (USFWS 2000). Severe long-term riparian vegetation losses have occurred in this part of the Sacramento River, and there are large open gaps without the presence of important habitat features due to the high amount of riprap (USFWS 2000). Between Verona and Collinsville on the Sacramento River (RMs 80-0) the river is even more ecologically degraded having been impacted by bank protection and riprapping (USFWS 2000). Overall, more than half of the Sacramento Rivers banks in the lower 194 miles have been riprapped (USFWS 2000).

Jones and Stokes (2006a), Stillwater Sciences (2006), and CDWR (2006) estimated the approximate percent of linear coverage of existing (pre-project) revetment, riparian vegetation, and IWM at the levee repair sites. Overall, repair sites currently contain approximately between 44 and 70 percent revetment, 10 to 54 percent riparian vegetation, and 17 to 28 percent IWM (Table 6).

Table 6. Approximate pre-project percent revetment, percent riparian vegetation, and percent IWM in the action area. Percentages were averaged using pre-project values in Jones and Stokes (2006a), Stillwater Sciences (2006), and CDWR (2006).

% Revetment	% Riparian	% IWM
44-70	10-54	17-28

3. <u>Southern DPS of North American Green Sturgeon</u>

The action area is utilized by the Southern DPS of North American green sturgeon adults for holding and migration purposes. North American green sturgeon holding habitat consists of the bottoms of deep pools where velocities are lowest often in off-channel coves or low-gradient reaches of the main channel (Erickson *et al*. 2002). Erickson *et al*. (2002) also found many of these sites were also found close to sharp bends in the Rogue River.

The high number of diversions in the action area on the Sacramento River and in the north Delta are a potential threat to the Southern DPS of North American green sturgeon. It is assumed larval green sturgeon are susceptable to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal behavior (starting at day 6). Reduced flows in the action area likely affect year class strength of the Southern DPS of North American green sturgeon as increased flows have been found to improve year class strength.

Adult migration barriers in the action area include the Sacramento Deep Water Ship Channel locks, Fremont Weir, and DCC Gates. These barriers can delay migration of Southern DPS North American green sturgeon affecting reproductive capacity and general health. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for green sturgeon survival (NMFS 1996). In addition, juvenile and adult green sturgeon are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges in the action area.

The transformation of the Sacramento River from a meandering waterway lined with dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the rivers sinuosity (USFWS 2000). In addition, the change in the ecosystem as a result of the removal of riparian vegetation and IWM likely impacted potential prey items and species interaction that green sturgeon would experience while holding. The effects of channelization on upstream migration of green sturgeon are unknown.

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile Southern DPS of North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthic (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the massive channelization effort in the action area has resulted in a loss of ecosystem properties (USFWS 2000, Sweeney *et al*. 2004). Channelization results in reduced food supply (aquatic invertebrates), and reduced pollutant processing, organic matter processing, and nitrogen uptake (Sweeney *et al*. 2004).

B. Factors Affecting the Species and Habitat in the Action Area

Because the size of the action area encompasses much of the applicable Sacramento River winter-run and CV spring-run Chinook salmon ESUs, and the CV steelhead DPS as well as the Southern DPS of North American green sturgeon, many of the factors affecting the species are discussed in the *Status of the Species and Habitat section* of this biological opinion. This section will focus on portions of the action area that are most relevant to the general location of the proposed action.

1. <u>Sacramento River Winter-run Chinook Salmon, Central Valley Steelhead, and Spring-run Chinook Salmon</u>

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed salmonids in the action area. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks. Consequently, the mainstream of the river often remains too high and turbid to provide quality rearing habitat. High water temperatures also limit habitat availability for listed salmonids in the lower Sacramento River. High summer water temperatures in the lower Sacramento River can exceed 72 ^{o}F, and create a thermal barrier to the migration of adult and juvenile salmonids (Kjelson *et al*. 1982). In addition, water diversions, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months limiting the survival of juvenile salmonids (Reynolds *et al*. 1993). Impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, and water quality, NIS, commercialization, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

Levee construction and bank protection have affected salmonid habitat availability and the processes that develop and maintain preferred habitat by reducing floodplain connectivity, changing riverbank substrate size, and decreasing riparian habitat and SRA. Individual bank protection sites typically range from a few hundred to a few thousand lf in length. Such bank protection generally results in two levels of impacts to the environment: (1) site-level impacts which affect the basic physical habitat structure at individual bank protection sites; and (2) reach-level impacts which are the accumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach (USFWS 2000). Revetted embankments result in loss of sinuosity and braiding and reduce the amount of aquatic habitat.

Impacts at the reach level result primarily from halting erosion and controlling riparian vegetation. Reach-level impacts which cause significant impacts to fish are reductions in new habitats of various kinds, changes to sediment and organic material storage and transport, reductions of lower food-chain production, and reduction in IWM.

The use of rock armoring limits recruitment of IWM (*i.e.*, from non-riprapped areas), and greatly reduces, if not eliminates, the retention of IWM once it enters the river channel. Riprapping creates a relatively clean, smooth surface which diminishes the ability of IWM to become securely snagged and anchored by sediment. IWM tends to become only temporarily snagged along riprap, and generally moves downstream with subsequent high flows. Habitat value and ecological functioning aspects are thus greatly reduced, because wood needs to remain in place to generate maximum values to fish and wildlife (USFWS 2000). Recruitment of IWM is limited to any eventual, long-term tree mortality and whatever abrasion and breakage may occur during high flows (USFWS 2000). Juvenile salmonids are likely being impacted by reductions, fragmentation, and general lack of connectedness of remaining nearshore refuge areas.

The Corp's SRBPP constructed bank protection projects at RM 149 in 2001, and 56.7 in 2004. The RM 149 project included conservation measures recommended by NMFS and the USFWS to remove the jeopardizing effects of the action constructing a set-back levee, or other conservation measures identified by the IWG that create or restore floodplain habitats, create additional riparian habitat, increase IWM recruitment, or improve the growth and survival of listed salmon and steelhead in the action area. The biological opinion required Corps to initiate a programmatic consultation for the SRBPP and to develop a comprehensive aquatic monitoring and evaluation program. The RM 56.7 project reaffirmed the commitment to implement conservation measures at RM 149, and described similar measures to minimize the effects of construction at RM 56.7. The RM 56.7 project also identified a timeline for implementing the conservation measures. As a result, off-site mitigation will be implemented on the right (*i.e.*, north) bank of the Lower American River, 0.5 miles above the confluence with the Sacramento River, and at a site on the Sacramento River, near RM 81. The Corps currently is drafting a draft biological assessment for NMFS to review prior to requesting a formal programmatic consultation. The Corps is committed to a comprehensive monitoring plan implementation in 2008. The Corps has awarded contracts for project-specific monitoring for 2007 to Stillwater Sciences until a plan can be developed in cooperation with CDWR. The current plan awarded to Stillwater Sciences addresses monitoring at all SRBPP sites constructed since 2001. The Corps will issue a request for proposals for 5 years of monitoring by July 1, 2007.

The Lower American River compensation project length is approximately 1,000 feet, the width varies from 0 to 300 feet measured from the edge of the river, and the project footprint is approximately 4 acres. This reach of the lower American River was substantially altered by the massive amounts of sediment deposited as a result of hydraulic mining in the upper watershed. The result is an elevated floodplain that has significantly altered the natural relationship between the river and the surrounding floodplain. The desirable vegetation communities are not reproducing and the floodplain is rarely available to fish. The Corps has issued a design contract, and construction will be initiated during 2007. The predominant project feature would be a large graded bench with an elevation range between 4 and 12 feet covering approximately a 2.0 acre area. The majority of this area is between elevation 5 and 9 feet. These elevations are designed to produce shallow inundation at average spring and winter river stages of 8 feet and 9.5 feet, respectively. The bench area grading includes two sloping depressions that are designed with inlets from the main channel to facilitate full drainage of the project site and reduce the risk of stranding fish during the transition to very low water river stages. Overall, the site will support a broad range of riparian habitat, providing a thick band of vegetation near the river and a less dense and varied palette over the rest of the project footprint. The design also includes the incorporation of IWM to provide enhanced fish cover along the bank and brush mattresses to control erosion. A distribution of relatively level benches at various elevations will provide shallow water for diverse salmonid rearing opportunities at target river stages. Preliminary SAM modeling for conceptual designs shows that the American River site will provide extensive habitat value that may fully compensate for the habitat losses at RM 149, and 56.7.

The Sacramento RM 82 site also offers opportunities for offsite mitigation if the American River site does not provide full compensation as to be determined through SAM modeling. The Corps is coordinating with CDWR to complete the real estate negotiations associated with acquiring the property. Once this is complete, a habitat restoration and enhancement project will be designed to compensate for past, and possibly future bank protection projects, as necessary.

The objectives of the lower American River restoration are to restore natural habitats that will benefit special-status species including Federally listed fish, and several other plant and wildlife species. A primary component is to create juvenile salmonid habitat by constructing a vegetated bench with a range of elevations that will be inundated by typical winter and spring river stages. The range of elevations is designed to provide shallow (*i.e.*, 1 to 3 feet) of inundation in the target seasons and to create several planting zones related to hydrologic characteristics. The planting zones will provide a mixture of vegetation types to protect against erosion and provide cover for salmonids. The grading and planting plan is also designed to minimize predator species habitat and eliminate potential fish stranding in an existing closed depression in the terrace at the site. The project design is intended to be consistent with management objectives for Discovery Park, including those presented in the River Corridor Management Plan for the Lower American River.

In November 2006, The Corps SRBPP and CDWR's Division of Engineering constructed 33 critical levee erosion repair projects in the Sacramento River, the Bear River, and in Steamboat and Cache Sloughs. The Corp's SRBPP constructed bank protection repairs at thirteen sites, along the Sacramento River between RMs 26.9 and 123.5. CDWR constructed bank protection repairs at sixteen sites in the SRFCP. Ten sites were along the Sacramento River, two sites were along the Bear River, two sites were along Cache Slough, one sight was along Steamboat Slough, and one site was along Butte Creek. A setback levee was constructed at RM 145.9 to avoid adverse impacts to sensitive aquatic resources. These projects placed rock and wood revetments along the waterside slope of each erosion site. One repair along the Sacramento River was a set-back levee. Overall, these projects reinforced approximately 25,801 lf of shoreline, covering approximately 50.9 acres, with 26.4 acres of rock riprap placed below the MSW. The area above the MSW was covered with soil and planted with riparian vegetation at all Corps and some CDWR sites. Seasonally inundated benches total approximately 11.6 acres. Approximately 6,795 lf of IWM was placed both above the MSW and 7,346 lf was placed below the MSW.

Similar to the proposed action, the previous 33 bank protection projects were designed to repair bank and levee erosion and restore and enhance the riparian and SRA habitat. Generally, this was accomplished by incorporating rock benches, that serve as buffers against extreme toe scour and shear stress while providing space for planting riparian vegetation and creating a platform to support aquatic habitat features. This approach recreates the elements of natural SRA habitat that otherwise would be lost as a result of project construction activities and continued erosion. Implementation of these conservation measures was meant ensure that long-term impacts associated with existing, and future bank protection projects are compensated in a way that prevents incremental habitat fragmentation and reductions of the conservation value of aquatic habitat to anadromous fish within the action area. Successful implementation of all conservation measures is expected to improve migration and rearing conditions for juvenile anadromous fish by increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area.

Despite the integrated conservation measures, long- and short-term impacts are expected. Primarily, long-term (*i.e.*, 5 to 50 year) impacts to listed salmonids will occur in the form of injury or death to juveniles summer and fall water surface elevations from the modification of shoreline habitat and the loss of IWM and other SRA. Short-term (*i.e.*,1 to 5 year) effects will occur at winter and spring water surface elevations, primarily from the temporary reduction of IWM and riparian vegetation. Overall, substantial long-term improvements are expected for the life of the project due to the construction of benches, the application of soil and IWM, and the extensive planting of riparian vegetation.

Preliminary reviews of the 33 sites indicate that construction at CDWR sites removed substantially more riparian vegetation, and placed less IWM than was initially anticipated by

NMFS. Additionally, much of the soil placement and revegetation plans were postponed until the spring of 2007 due to construction delays and a shortage of a suitable stock of plants. However, CDWR intends to place soil and plant riparian vegetation as soon as possible once site conditions allow. Additionally, as a condition of the June 21, 2006, biological opinion, amended on October 18, 2006, CDWR must coordinate with the Corps to develop a habitat and species compensation strategy and implement any actions necessary to fully compensate for unavoidable impacts within 12 months. CDWR also will conduct a follow-up SAM analysis and will conduct several years of SAM-related monitoring. If the habitat values do not meet the modeled values, additional compensation measures will be implemented. Because of this, NMFS expects that the compensation requirements will be followed and that the project impacts and improvements ultimately will meet NMFS expectations.

The biological opinions written since 2001 have emphasized the need for a comprehensive monitoring and evaluation program.

2. <u>Southern DPS of North American Green Sturgeon</u>

PS and NPS pollution resulting from agricultural discharge and urban and industrial development occurs in the action area. The effects of these impacts are discussed in detail in the *Status of the Species and Habitat* section. Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates of green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995). Principle sources of organic contamination in the Sacramento River are rice field discharges from Butte Slough, USBR District 108, Colusa Basin Drain, Sacramento Slough, and Jack Slough (USFWS 1995). In addition, organic contaminants from agricultural returns, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of green sturgeon. The high number of diversions in the action area on the Sacramento River and in the north Delta are a potential threat to North American green sturgeon. Other impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, and water quality, NIS, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

The transformation of the Sacramento River from a meandering waterway lined with a dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the rivers sinuosity (USFWS 2000). In addition, the change in the ecosystem as a result of the removal of riparian vegetation and IWM likely impacted potential prey items and species interaction that green sturgeon would experience while holding. The effects of channelization on upstream migration of green sturgeon are unknown.

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthic (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the massive channelization effort in the action area has resulted in a loss of ecosystem properties (USFWS 2000, Sweeney *et al*. 2004). Channelization results in reduced food supply (aquatic invertebrates), and reduced pollutant processing, organic matter processing, and nitrogen uptake (Sweeney *et al*. 2004).

C. Likelihood of Species Survival and Recovery in the Action Area

A majority of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead currently utilize the Sacramento River for rearing and migration. Some of these fish are expected to use off-channel estuarine areas in Steamboat sloughs for rearing and migration. Although the fish habitat in these areas is currently degraded, they have high conservation value for the species because of their location, and the habitat features they provide that are essential to fulfilling certain life history requirements such as growth during outmigration. Recent improvement in bank protection practices that integrate fish habitat features will contribute to improvements of habitat condition and function throughout the action area.

In their recent evaluation of the viability of Central Valley salmonids, Lindley *et al*. (2006a) found that extant populations of Sacramento River winter-run Chinook salmon and CV steelhead appear to be fairly viable. These populations meet the several viability criteria including population size, growth, and risk from hatchery strays. The viability of the ESU to which these populations belong appears low to moderate, but the ESU remains vulnerable to extirpation due to their small-scale distribution and high likelihood of being affected by a significant catastrophic event. Lindley *et al*. were not able to determine the viability of existing steelhead populations, but believe that the DPS has a moderate to high risk of extirpation since most of the historic habitat is inaccessible due to dams, and because the anadromous life-history strategy is being replaced by residency.

The southern DPS of North American green sturgeon utilize the mainstem Sacramento River for spawning, rearing, and migration purposes. In addition, the Southern DPS of North American green sturgeon are known to occur in Delta areas, and recently have been seen in the Feather and Yuba River. Habitats of the Sacramento River are very important for the Southern DPS of North American green sturgeon as they are the only know location of spawning (upstream) and the habitat features provide for essential life history requirements during larval rearing, juvenile and adult migration, and adult holding. Recent population estimates indicate that there are few fish relative to historic conditions, and that loss of habitat has affected population size and distribution. However, sturgeon remain widely distributed along the Pacific coast from California to Washington, and recent findings of fish in the Feather and the Yuba River indicate that their distribution in the Central Valley may be more broad that the previously thought. This suggests that the DPS probably meets several VSP criteria for distribution and diversity, and indicates that the Southern DPS of North American green sturgeon faces a low to moderate risk of extirpation.

Based on these viability assessments, and the recent habitat improvements that occurring throughout the action area to improve the conservation value of aquatic habitat for listed fish, Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the southern DPS of North American green sturgeon are likely to continue to survive and recover in the action area.

V. EFFECTS OF THE ACTION

A. Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This biological opinion assesses the effects of the proposed action on endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CV steelhead, their designated critical habitat, and threatened Southern DPS of North American green sturgeon.

In the *Description of the Proposed Action* section of this biological opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this biological opinion, NMFS provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536).

NMFS generally approaches "jeopardy" analyses in a series of steps. First, we evaluate the available evidence to identify the direct and indirect physical, chemical, and biotic effects of proposed actions on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound. Once we have identified the effects of an action, we evaluate the available evidence to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). We then use the evidence available to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

To evaluate the effects of the proposed action, NMFS examined proposed construction activities, O&M activities, habitat modification, and conservation measures, to identify likely impacts to listed anadromous salmonids within the action area based on the best available information.

The information used in this assessment includes fishery information previously described in the *Status of the Species* and *Environmental Baseline* sections of this biological opinion; studies and accounts of the impacts of riprapping and in-river construction activities on anadromous habitat and ecosystem function; and documents prepared in support of the proposed action, including the December 2006 EA (Corps 2006); SAM results; project designs; project designs, field reviews of Corps-led sites constructed during the summer and fall months of 2006, and meetings held between the Corps, NMFS, USFWS, and CDFG.

B. Assessment

The assessment will consider the nature, duration, and extent of the proposed action relative to the migration timing, behavior, and habitat requirements of Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon. Specifically, this assessment will consider the potential impacts related to construction and O&M activities, and will use the SAM model (Corps 2004) to assess species response to habitat modifications from proposed bank protection projects over a 50-year period. At this time, the SAM does not apply to green sturgeon. Therefore, long-term impacts to green sturgeon will be evaluated separately from impacts to anadromous salmonids.

The assessment of effects considers the potential occurrence of Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon, relative to the magnitude, timing, frequency, and duration of project activities. Effects of the proposed project on aquatic resources include both short- and long-term impacts. Short-term effects, which are related primarily to construction activities (*i.e.*, increased suspended sediment and turbidity), may last several hours to several weeks. O&M impacts are related to annual actions necessary to maintain project features and may occur for the life of the project (*i.e.*, 50 years). Long-term impacts may last months or years and generally involve physical alteration of the river bank and riparian vegetation adjacent to the water's edge.

The project sites are downstream from the spawning habitat of Chinook salmon, steelhead, and the Southern DPS of North American green sturgeon. Therefore, no short- or long-term effects on spawning habitat are expected.

1. Short-term Construction-related Impacts

In-water construction activities, including the placement of rock revetment, could result in direct effects to fish from the placement of rock into occupied habitat during peak migration periods. The project would result in localized, temporary disturbance of habitat conditions that may alter natural behavior patterns of adult and juvenile fish and cause the injury or death of individuals. These effects may include displacement, or impairment of feeding, migration, or other essential behaviors by adult and juvenile salmon, steelhead, and green sturgeon from noise, suspended sediment, turbidity, and sediment deposition generated during in-water construction activities. Some of these effects could occur in areas downstream of the project sites, because noise and sediment may be propagated downstream.

Construction will occur between November 13, 2006, and November 30, 2007, and will affect approximately 9,817 lf of river and slough bank and channel bottom. Specifically, construction will affect 8,771 lf of the Sacramento River, and 1,046 lf of Steamboat Slough. Phase 1, from November 13, 2006 to June 1, 2007, will involve the placement of toe rock to provide immediate stability to critical sites. Phase 2, will involve limited construction below the water line, but will affect riparian and shoreline areas primarily above the summer water surface elevation.

The extent of construction-related effects is dependant upon the timing of fish presence in the action area, and their ability to successfully avoid project-related disturbance. Construction will occur from November 13, 2006, through November 1, 2007. Phase one construction will occur from November 13, 2006 through June 1, 2007, and coincides with the peak migration periods of all Federally listed anadromous fish species. Peak winter-run Chinook salmon emigration in the action area occurs between November and January, and commonly coincides with initial flow increases of up to 20,000 cfs, which occur from December through February. Juvenile CV spring-run Chinook salmon and CV steelhead migration can begin as early as November, but similar to winter-run, the peak migration occurs during sustained high flow periods between December and March. Sacramento River winter-run Chinook salmon are expected to be present in the action area from December through May. CV spring-run Chinook are expected in the action area from January through July, and CV steelhead will be present from November through May of Phase 1, and from September through November during Phase 2.

Green sturgeon larvae and post-larvae are present in the action area between June and October with highest abundance during June and July (CDFG 2002), and remain in freshwater portions of the Delta for up to 10 months (Kynard *et al.* 2005). In addition, small numbers of juvenile sturgeon less than two years of age have been captured in the action area sporadically in the past (Jeff McLain, NMFS, pers. comm., 2006). Adult green sturgeon holding occurs in the Sacramento River in deep pools for up to six months per year, primarily between March and July (USFWS 2002).

a. *Potential Direct Effects from Rock Placement into Occupied Aquatic Habitat*

(1) *Salmon and Steelhead*

The placement of rock below the waterline will cause noise and physical disturbance that could displace juvenile and adult fish into adjacent habitats, or crush and injure or kill individuals. The impact of rock being placed in the river disrupts the river flow by producing surface water waves disturbing the water column; resulting in increased turbulence and turbidity. Migrating juveniles react to this situation by suddenly dispersing in random directions. This displacement can lead them into predator habitat where they can be targeted, and injured and killed by opportunistic predators taking advantage of juvenile behavioural changes. Carlson *et al*. (2001) observed this behaviour occurring in response to routine channel maintenance activities in the Columbia River. Some of the fish that did not immediately recover from the disorientation of turbidity and noise from channel dredges and pile driving swam directly into the point of contact with predators. Feist (1991) found that noise from pile driving activities in the Puget Sound affected the general behaviour of juveniles by temporarily displacing them from construction areas. Nearly twice as many fish were observed at construction sites on non-pile driving days compared to days when pile driving occurred.

Biological studies conducted at GCID also support that predation may be higher in areas where juveniles are disoriented by turbulent flows or are involuntarily routed into high-quality predator habitat or past areas with higher predator densities (Vogel 2006). Behavioural observations of predator and salmon interactions at GCID also surmised that predators responded quickly to the release of fish during the biological tests and preyed on fish soon after they were released into the water, even when the release locations were periodically changed (David Vogel, Natural Resource Scientists, pers. comm. 2006). This is a strong indication that predators quickly respond to changes in natural juvenile salmonid behavioural responses to disturbance.

NMFS was unable to find any scientific evidence that fish may be injured or killed by crushing from rock placement. Regardless, many juvenile fish are small, relatively slow swimmers, typically found in the upper two feet of the water column, and oriented to nearshore habitat. Larger fish, including adults and smolts probably would respond by quickly swimming away from the placement site, and would escape injury or death. Fry-sized fish (those that are less than 50mm) that are directly in the path of rock placement may be less likely to avoid the impact. Therefore, it appears likely that the placement of large quantities into this habitat has the potential to crush and injure or kill fry-sized salmon and steelhead. However, the best available outmigration data throughout the Sacramento River, indicate that fry-size listed salmon or steelhead are unlikely to be present in the action area during the construction period, unless flood conditions wash fish downstream. In such a case, the Corps would suspend construction until flows subsided. Therefore, it appears to be unlikely that salmon and steelhead will be injured or killed from being crushed by rock.

The operation of heavy equipment such as crane mounted barges and the sound generated by construction activities may temporarily affect the behavior of migrating adult salmonids, possibly causing migration delays. However, construction activities are not likely to injure or kill adult winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead because of their crepuscular migration behavior, and because these fish tend to utilize mid-channel, deep water habitats. Construction will be restricted to the channel edge, and would include implementation of the avoidance and minimization measures that will prevent impacts to these migration corridors.

(2) *Green Sturgeon*

Rock placement will occur while green sturgeon are present in the action area. In-water activities could cause injury or mortality to individual green sturgeon that do not readily move away from the areas directly affected by rock placement. However, NMFS expects that since juvenile and adult green sturgeon show a preference for benthic habitat types, few fish should be exposed to rock placement along the shoreline, and construction activities are not likely to injure or kill juveniles or adults.

b. *Potential Effects of Sediment and Turbidity*

Rock placement and nearshore construction will disturb soils and the riverbed and result in increased erosion, siltation, and sedimentation. Short-term increases in turbidity and suspended sediment may disrupt feeding activities of fish or result in temporary displacement from preferred habitats.

(1) *Salmon and Steelhead*

Numerous studies show that suspended sediment and turbidity levels moderately elevated above natural background values can result in non-lethal detrimental effects to salmonids. Suspended sediment affects salmonids by decreasing reproductive success, reducing feeding success and growth, causing avoidance of rearing habitats, and disrupting migration cues (Bash *et al.* 2001). Sigler *et al.* (1984) in Bjornn and Reiser (1991), found that prolonged turbidity between 25 and 50 Nephelometric Turbidity Unit (NTUs) reduced growth of juvenile coho salmon and steelhead. Macdonald *et al.* (1991) found that the ability of salmon to find and capture food is impaired at turbidities from 25 to 70 NTUs. Bisson and Bilby (1982) reported that juvenile coho salmon avoid turbidities exceeding 70 NTUs. Increased sediment delivery can also fill interstitial substrate spaces and reduce cover for juvenile fish (Platts *et. al.* 1979) and abundance and availability of aquatic invertebrates for food (Bjornn and Reiser 1991). We expect turbidity to affect Chinook salmon and steelhead in much the same way that it affects other salmonids, because of similar physiological and life history requirements between species.

Newcombe and Jensen (1996) believe that impacts on fish populations exposed to episodes of high suspended sediment may vary depending on the circumstance of the event. They also believe that wild fish may be less susceptible to direct and indirect effects of localized suspended sediment and turbidity increases because they are free to move elsewhere in the system and avoid sediment related effects. They emphasize that the severity of effects on salmonids depends not only on sediment concentration, but also on duration of exposure and the sensitivity of the affected life stage.

Suspended sediment from construction activities would increase turbidity at the project site and could continue downstream. Although Chinook salmon, steelhead, are highly migratory and capable of moving freely throughout the action area, an increase in turbidity may injure fish by temporarily disrupting normal behaviors that are essential to growth and survival such as feeding, sheltering, and migrating. Injury is caused when disrupting these behaviors increases the likelihood that individual fish will face increased competition for food and space, and experience reduced growth rates or possibly weight loss. Project-related turbidity increases may also affect the sheltering abilities of some fish and may decrease their likelihood of survival by increasing their susceptibility to predation.

Construction activities are expected to result in periodic turbidity levels that exceed 25 to 75 NTUs, and thus capable of affecting normal feeding and sheltering behavior. Based on observations during similar construction activities in the Sacramento River, turbidity plumes are not expected to extend across the Sacramento River, but rather the plume is expected to extend downstream from the site along the side of the channel. Turbidity plumes will occur during daylight hours during in-water construction. At a maximum, these plumes are expected to be as wide as 100 feet, and extend downstream for up to 1,000 feet. Most plumes extend into the channel approximately 10 to 15 feet, and downstream less than 200 feet. Once construction stops, water quality is expected to return to background levels within hours. Adherence to erosion control measures and BMPs such as use of silt fences, straw bales and straw wattles will minimize the amount of project-related sediment and minimize the potential for post-construction turbidity changes. Since project-related turbidity plumes will be limited to shoreline construction areas, NMFS expects that individual fish will mostly avoid the turbid areas of the river. For those fish that do not avoid the turbid water, exposure is expected to be brief (*i.e.*, minutes to hours) and not likely to cause injury or death from reduced growth, or physiological stress. This expectation is based on the general avoidance behaviors of salmon and the Corps proposal to suspend construction when turbidity exceeds Regional Board standards. Once fish migrate past the turbid water, normal feeding and migration behaviors are expected to resume. However, those juveniles that are exposed to project construction are expected to encounter short-term (*i.e.*, minutes to hours) construction-related water quality changes that will cause injury or death to some individuals by temporarily disrupting normal behaviors, affecting juvenile sheltering abilities, and increasing their susceptibility to predation.

(2) *Green Sturgeon*

Green sturgeon will be present in the action area during construction, and therefore may be exposed and affected by short-term increases in turbidity and suspended sediment if these increases disrupt feeding and migratory behavior activities of post-larvae, juvenile, and adult fish. Turbidity and sedimentation events are not expected to affect visual feeding success of green sturgeon, as they are not believed to utilize visual cues (Sillman *et al.* 2005). Instead, olfaction appears to be a key feeding mechanism. In addition, green sturgeon are primarily benthic, and their presence along the shoreline is not expected to be common. Therefore, adverse effects including injury or death from temporary increases in sediment and turbidity are not likely.

c. *Other Potential Water Quality Effects*

Toxic substances used at construction sites, including gasoline, lubricants, and other petroleum-based products could enter the Sacramento River as a result of spills or leakage from machinery or storage containers and injure or kill listed salmon, steelhead, and green sturgeon. These substances can kill aquatic organisms through exposure to lethal concentrations or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality. Petroleum products also tend to form oily films on the water surface that can reduce DO levels available to aquatic organisms. NMFS expects that adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak. NMFS does not expect the project to result in water contamination that will injure or kill individual fish.

d. *Summary of Construction-related Effects*

(1) *Salmon and Steelhead*

NMFS expects that a large, but unknown, number of anadromous salmonids will be present in the action area during Phase 1 construction because of the peak migration periods that occur during this time. Those fish that are exposed to project construction will encounter short-term (*i.e.*, minutes to hours) construction-related noise, physical disturbance, and water quality changes that may cause injury or death by increasing the susceptibility of some individuals to predation by temporarily disrupting normal behaviors, and affecting sheltering abilities. Some juvenile fish may be crushed, and killed or injured during rock placement. Others may be displaced from natural shelter and preyed upon by piscivorous fish. Although construction will occur during peak migration periods, relatively few juvenile fish are expected to be injured or killed by in-river construction activities because most fish are expected to avoid construction activities due to their predominately crepuscular migration behaviors. The implementation of BMPs and other on-site measures also will minimize impacts to the aquatic environment and reduce project-related effects to fish. In addition, peak migration events correspond with periods of high river flows, when in-river construction activities are likely to be suspended. Furthermore, only one cohort, or emigrating year class, out of perhaps four to five within each salmon and steelhead population will be affected. Therefore, NMFS expects that actual injury and mortality levels will be low relative to the overall population abundance, and not likely to result in any long-term, negative population trends. Adults should not be injured because their size, preference for deep water, and their crepuscular migratory behavior will enable them to avoid most temporary, nearshore disturbance.

(2) ***Green Sturgeon***

NMFS expects that a large, but unknown, number of green sturgeon will be present in the action area during Phase 1 construction because of the peak migration periods that occur during this time. Green sturgeon are primarily benthic, and their presence along the shoreline is not expected to be common. Therefore, adverse effects including injury or death from construction activities are not likely.

e. *Construction-related effects to Critical Habitat*

Constuction activities will alter the site-scale physical characteristics of the PCEs of salmon and steelhead critical habitat, including elements of freshwater and estuarine rearing and migration habitat. These effects are discussed in detail below in *Section 3, Long Term Impacts as Projected by the SAM Model*. Impacts that occur during construction are quantified in the SAM analysis as effects that occur in year 1.

2. Effects of Project Operation and Maintenance

O&M activities are expected to occur between July 1 and November 30 for the life of the project (*i.e.*, 50 years) to maintain the flood control and environmental values of the site. Anticipated O&M actions include vegetation management and irrigation for up to three years, periodic rock placement to prevent or repair localized scouring, and periodic replacement or modification of IWM structures. Effects would be limited to the annual placement of up to 600 cubic yards of material, except that they will be smaller and localizied. Impacts from O&M actions generally will be similar to the impacts of initial construction, and include injury or death to salmon and steelhead from predation cause by turbidity changes that temporarily disrupt normal behaviors, and affect sheltering abilities. However, since O&M actions are only expected to repair damaged elements of the project, they are expected to be infrequent (*i.e.*, occurring only once every several years), small (*i.e*, only affecting small sections of the project area), and will not occur at all sites. Therefore relatively few fish should be affected by O&M actions, and actual injury and mortality levels will be low relative to overall population abundance and not likely to cause any long-term, negative population responses. O&M actions that affect habitat conditions BMPs, summer in-water construction windows, and other minimization and avoidance measures will be implemented to reduce these effects to anadromous salmonids, green sturgeon, and their habitat.

3. Long Term Impacts as Projected by the SAM Model

The project is expected to result in long-term habitat modifications, including modifications to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. The modifications will affect fish behavior, growth and survival, and the PCEs of critical habitat including freshwater and estuarine rearing sites and migration corridors.

Long-term project effects include the alteration of river hydraulics and cover along approximately 9,817 lf of shoreline as a result of changes in bank configuration and structural features. These changes may affect the quantity and quality of nearshore habitat for juvenile Chinook salmon, steelhead. Simple revetted slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit the deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators.

Removal of riparian vegetation and IWM from stream banks results in the temporal loss of a primary source of overhead and instream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project. As a result, habitat diversity, complexity, and quality for survival and growth are diminished.

Several project features were designed to address the need for ecologically functional shallow-water, floodplain habitat, riparian habitat, and cover in the confined reaches of the lower Sacramento River. The inclusion of a low bench, plantings of emergent wetland and riparian vegetation, and placement of IWM will help restore habitat diversity. Irregular shorelines, riparian vegetation, IWM, and variability in bench elevations are expected to create low-velocity zones of deposition where sediment and organic material will be stored and made available to aquatic invertebrates and other decomposers. Vegetated low benches also will provide high-quality shallow water habitat for fish during winter and spring that will increase in value over time, as the vegetation becomes established.

Riparian vegetation along streams provides shade, which incrementally moderates stream temperatures and prevents direct solar exposure of fish at shallow depths. The role of riparian shade in moderating stream temperatures is greatest on small streams and decreases with increasing stream size. Because of the large size of the Sacramento River, relative to its existing shoreline canopy, the effect of riparian vegetation in moderating water temperatures is minor, compared with the effects of reservoir operations, discharge, and meteorological conditions. Similarly, the effect of shade on Steamboat Slough is minimal, primarily because of the low elevations and extremely warm summer air temperatures.

Most importantly, the removal of riparian vegetation reduces the potential recruitment of IWM and diverse fish habitat features at the project site and downstream. Minimizing the removal of existing riparian vegetation will reduce project impacts on IWM recruitment. However, for the purpose of the SAM assessment, it is assumed that up to 40 percent of the existing shoreline riparian canopy may be affected by project implementation. This is a very rough estimate, as effects to the riparian canopy will be necessary only to facilitate the placement of rock from a barge. Similarly, although all IWM will be left in place, some IWM will be covered with rock, and the SAM assessment assumes that up to 50 percent of the function of existing IWM will be lost to construction. Extensive revegetation, and installation of additional IWM is expected to reduce these impacts and losses of function.

a. *SAM Analysis*

Long-term project effects to critical habitat and salmonid responses to such changes are measured in terms of the length and area of bank and channel bed disturbed by construction, and the quantity and quality of habitat as measured by the SAM. The SAM was developed by the Corps, in consultation with NMFS, USFWS, CDFG and CDWR, to address specific habitat assessment and regulatory needs for ongoing and future bank protection actions in the SRBPP action area. The SAM was designed to address a number of limitations associated with previous habitat assessment approaches and provide a tool to systematically evaluate the impacts and compensation requirements of bank protection projects based on the needs of listed fish species (with the exception of Southern DPS green sturgeon). A major advantage of the SAM is that it integrates species life history and flow-related variability in habitat quality and availability to generate species responses to project actions over time. Species responses represent an index of a species growth and survival based on a 30-day exposure to post project conditions at a variety of seasons and life-history stages, over the life of the project.

In general, the SAM quantifies habitat values in terms of a bank line or area-weighted species response index (WRI) that is calculated by combining habitat quality (*i.e.*, fish response indices) with quantity (*i.e.*, bank length or wetted area) for each season, target year, and relevant species/life stage. The fish response indices are derived from hypothesized relationships between key habitat variables and the responses of individual species and life stages. Rearing and outmigrating Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead responses to habitat variables tend to be similar, although seasonal presence and exposure may vary.

The response indices vary from 0 to 1, with 0 representing unsuitable conditions and 1 representing optimal conditions for survival and growth. For a given site and scenario (*i.e.*, with or without project), the SAM uses these relationships to determine the response of individual species and life stages to the measured or predicted values of each variable for each season and target year, and then multiplies these values together to generate an overall species response index. This index can then multiplied by the area or lf of bank or the project area to which it applies to generate a weighted species response index, expressed as feet or square feet. The species response index provides a common metric that can be used to quantify habitat values over time, compare project alternatives to existing conditions, and evaluate the effectiveness of on-site and off-site compensation actions. Positive SAM results are a relative index of improved growth and survival conditions, and negative results index declining growth and survival conditions, or injury and death.

The SAM (Corps 2004) employs the following six habitat variables to characterize nearshore and floodplain habitats of listed fish species:

- Bank slope – This is the average bank slope along each average seasonal water surface elevation. Bank Slope is an indicator of shallow-water habitat availability, which is important for juveniles for feeding, rearing, and refugia from high flows and predators. The relationship of bank slope to fish response is related to how variations in fish size and foraging strategies affect growth potential and expose various species and life stages to predation risk. For fry and smolts of each species, shallow water near the bank is considered to be high value because it provides refuge from predators and low velocity feeding and rearing habitat (Power 1987, Waite and Barnhart 1992, and Schlosser 1991). Smaller fish can avoid predation by piscivorous fish to some degree by selecting shallower water. Although larger fish (*i.e.*, smolts) typically use deeper water habitats, it is assumed that predation risk also increases. Adult life stages are not affected by the same predation as juveniles and tend to utilize deep, mid-channel habitat as migratory corridors. Therefore, adults are not expected to be sensitive to changes in bank slope.

  For the purpose of the Corps (2006) assessment, the bank slope extending from each seasonal shoreline to a depth of 3 ft was used for each site to characterize with-project shallow water habitat availability. Depths were obtained from Ayres (2006) preliminary design drawings Geographical information systems (GIS) was used to estimate existing seasonal shoreline slopes.

- Floodplain availability – This is the ratio of wetted channel and floodplain area during the 2-year flood to the wetted channel area during average winter and spring flows. Floodplain availability is used as an indicator of seasonally flooded shallow-water habitat availability, which is important for juveniles for feeding, rearing, and refugia from high flows and predators. Use of seasonally inundated flooded habitat is generally considered to increase growth of juvenile salmonids due to greater access to areas with high invertebrate productivity from flooded terrestrial matter (Sommer *et al.* 2001). Predation risk in seasonally flooded areas is expected to be less in seasonally inundated areas with large amounts of hiding cover and a lack of piscivorous fish. Adult life stages tend to utilize deep, mid-channel habitat and are not expected to be sensitive to changes in floodplain availability.

  For the Corps (2006) assessment, GIS was used to estimate the wetted surface areas corresponding to each seasonal water elevation. The floodplain inundation ratio for all sites was 1 to 1.2, indicating the narrowly confined channel between the levees.

- Bank substrate size – This is measured as the median particle diameter of the bank (*i.e.*, D50) immediately below (*i.e.*, 0 to 3 feet) each average seasonal water surface elevation.

Bank substrate size is used as an indicator of juvenile refugia from predators, but also as an indicator of suitable predator habitat. Increased predator density has been observed at riprapped sites relative to natural banks at studies in the Sacramento River and the Delta (Michny and Deibel 1986, Michny 1989). Substrate size also is used as an indicator of food availability. The effects of substrate size on mortality risk are expected to be greatest at small grain sizes due to a lack of cover from avian and piscivorous fish predation. Predation risk is lower at intermediate sizes close to the size of the affected life stage because small interstitial spaces offer cover from predators. Predation risk is highest when grain sizes exceed the length of the affected life stage, because interstitial spaces are capable of providing effective cover for piscivorous fish species. Adult life stages tend to utilize deep, mid-channel habitat and are not expected to be sensitive to changes in bank substrate size.

For the Corps (2006) assessment, pre-project substrate sizes were obtained using previous survey and survey data. A value of 0.25 inches was applied to natural bank areas. For Phase 1, bank substrate size at all sites is approximately 12 inches to reflect that placement of large riprap. In Phase 2, from summer through year 50 of the SAM analysis, substrate size was assumed to average 4 inches for the soil-filled rock at the summer/fall WES, and 0.25 inches at the winter/spring water surface elevation, for the soil cover on the benches and banks.

- Instream structure – This is measured as the percent of shoreline coverage of IWM along each average seasonal water surface elevation. The value of instream structure to salmonids has been directly demonstrated by various studies. Instream structure is an indicator of juvenile refugia from predators (Michny and Hampton 1984, Michny and Deibel 1986). Instream structure is used as an indicator of food availability, feeding station availability, and as cover and resting habitat for adults. Instream structure provides high quality resting areas for adults and juveniles, cover from predation, and substrate for macroinvertebrate production (USFWS 2000, Lassettre and Harris 2001, Piegay 2002).

  For the Corps (2006) assessment, this variable was measured by estimating the percent of the shoreline at each site that is occupied by instream woody material within the inundation zone associated with each seasonal water surface elevation. For the purpose of the assessment, initial losses of IWM in Phase 1 would be replaced during Phase 2 of the project, in year 1 of the assessment. Since IWM will not be placed at sites downstream from Sacramento RM 33.0, the amounts were doubled at sites at, and upstream from Sacramento RM 33, and the extra values were credited to sites downstream from RM 33.0. Although this does not necessarily affect the response of fish to habitat changes downstream from RM 33.0, it represents an accounting mechanism for offsite compensation.

- Aquatic and submerged terrestrial vegetation – This is measured as the percent of shoreline coverage of aquatic or riparian vegetation along each average seasonal water surface elevation. Aquatic vegetation is used as an indicator of juvenile refugia from predators, and food availability. Rearing success is strongly affected by aquatic vegetation (Corps 2004). Biological response to aquatic vegetation is influenced by the potential for food production and cover to sensitive life stages. Because salmonid fry and juveniles are commonly found along shore in flooded vegetation (Cannon and Kennedy 2003) increases in aquatic and submerged terrestrial vegetation is expected to result in a positive salmonid response (*i.e.*, increased growth, reduced risk of predation). Adult salmonids are not expected to be sensitive to changes in aquatic or submerged terrestrial vegetation.

For the Corps (2006) assessment, measurements of the linear extent of aquatic vegetation were obtained from site surveys and through queries of the Corps riprap database. Phase 2 vegetation plans were used to estimate with-project conditions.

- Overhanging shade – This is measured as the percent of the shoreline coverage of shade along each average seasonal water surface elevation. The value of overhanging shade is an indicator of juvenile refugia from predators, and food availability. Numerous studies have shown the importance of overhanging shade to salmonids. Overhanging shade provides overhead cover, and allochthonous inputs of leaf litter and insects which provide food for juveniles. Michny and Hampton (1984), and Michny and Deibel (1986) juvenile salmonid abundance was highest in reaches of the Sacramento River with shaded riparian cover.

For the Corps (2006) assessment, measurements of the linear extent of overhanging shade were obtained from site surveys and through queries of the Corps riprap database. Phase 2 vegetation plans were used to estimate with-project conditions. The Corps assumed that all mature trees that currently shade the winter/spring shoreline would be maintained under with-project conditions. Initial (*i.e.*, year 0) shade values were conservatively estimated at 25 percent of existing conditions due to a combination of 2 factors. First, the placement of rock fill will shift the bankline intersection of the seasonal water surface elevations towards the channel centerline and away from the existing vegetation. Second, riprap placement will cover and effectively remove all mid- and low-canopy shade. Even with the riparian revegetation occurring at each site, little of no shade will be present for several (*i.e.*, 3 to 5 years). However, in the long-term, (*i.e.*, 5 to 50 years), expected overhanging shade will exceed existing conditions and eventually reach nearly 100 percent at the summer/fall shorelines as the vegetative growth extends over the waterline. The SAM was used to quantify the responses of the target fish species and life stages to with-project conditions over a 50-year project period relative to the species and life stage responses under without-project (existing) conditions. The assessment followed the general steps outlined in the SAM Users Manual (Stillwater Sciences and Dean Ryan Consultants & Designers 2004). All computations were performed using the electronic calculation template provided by Stillwater Sciences. The results are presented in terms of WRIs for each target species, life stages, and season of occurrence in the project area. Input data includes site- and reach-scale data on existing bank slope, floodplain availability, bank substrate size, instream structure, aquatic and submerged aquatic vegetation, and overhanging shade at four average seasonal water surface elevations.

SAM model results are summarized in Appendix B, Tables 1-32 through 1-45. Appendix B presents some of the tables found within Appendix I of the EA for Levee Repair of 14 Winter 2006 Critical Sites, Sacramento River Bank Protection Project (Corps 2006). To avoid confusion between documents Appendix B tables follow the Corps Appendix I numbering sequence. Results are shown for each species, at each average seasonal water surface elevation, over a 50 year period, at year 1, 5, 15, 15, and 50. The results are preliminary because the details of Phase 2 will be developed while Phase 1 is under construction. The SAM analysis will be repeated during or following construction to more accurately reflect as-built conditions. Results are summarized for Chinook salmon and CV steelhead at average seasonal water surface water surface elevations.

The model is capable of projecting how a without-project scenario conditions would change over time. However, the modeling for these projects compared the with-project conditions to a static existing baseline because it simplifies the interpretation of modeling results and because, based on site evaluations conducted by the Corps and NMFS, over a 50 year period, the baseline conditions probably would decline due to the limited amount of remaining high quality habitat. Also, given the critical state of the existing sites, the without-project scenario is likely to include emergency flood fighting that would result in substantial habitat degradation.

As with many models, SAM modeling is based on many assumptions about species behavior and response to habitat changes. There also are untested assumptions regarding the response of physical project elements to river flows and other unpredictable environmental events. Therefore, there is a considerable amount of uncertainty regarding the results. To account for some of the uncertainty, the Corps, NMFS, USFWS, and scientists from Stillwater Sciences discussed and agreed upon conservative model input variables that tend to generate worst-case scenarios based on conservative estimates of habitat modification and improvement overtime. The model itself accounts for some of the uncertainty by generating results at four different average water surface elevations. To account for site diversity, model input values are not measured only at discrete average flow elevations, but within three feet of these elevations. Although the model focuses on a discrete average water surface elevation, seasonal variability of average flows is accounted for in the project designs because project features, and conservation measures (*i.e.,* benches, vegetation, and IWM) are placed at variable elevations. Project-specific, and long-term comprehensive monitoring will measure the success of model results by evaluating habitat evolution and fish habitat use. These monitoring results will be used to make adaptive project modifications necessary to ensure that fish and habitat responses occur as predicted.

Further support for expectations regarding the physical response to habitat conditions over time is supported by the monitoring results for similar projects in the American and Sacramento Rivers. Riparian and SRA monitoring at eight bank protection or revegetation projects along the American River, demonstrated that riparian goals for tree and shrub width, height, cover, and shoreline cover were met or exceeded at all sites (Ross, 2006). At the Sand Cove bank protection project, along the Sacramento River, riparian establishment rates after year 1 were high, especially on the upper slope of the project. However, along the lower slope, and on the bench, sediment deposition ranging from six inches to four feet buried much of the willow cuttings and the surface of the rock bench. The extensive placement of IWM at the site (*i.e.*, approximately 80 percent shoreline coverage) may have played a role in the deposition by reducing local velocities. It is not yet known if the willows will emerge through the sediment, but the deposition and reduced shoreline velocities mimic natural floodplain processes that would not otherwise occur at a conventional bank protection project. Observations at the American River sites by staff from SAFCA, Jones and Stokes, and NMFS, found large numbers of salmon fry using project-constructed shallow-water habitat with integrated SRA, and NMFS has observed larval suckers using shallow water habitat refugia provided by the bench and the flooded IWM at the Sand Cover project.

a. *Long-term Effects of SRBPP Actions on Anadromous Salmonids*

(1) *Adult Migration*

Adult Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon migrate up the Sacramento River from December through July, and CV steelhead may migrate upstream from September through May. SAM model results show deficits at all sites for all anadromous species lasting from 1 to 50 years (Appendix B, Tables 1-32 to 1-45).

The SAM reporting results (Corps 2006) found that losses of riparian shade and IWM, may reduce habitat value for adult salmonids due to reduced cover available for resting and holding during upstream migration. Only at Sacramento River sites RM 68.9L and 78.0L would the eventual increase in summer and fall overhead cover be sufficient to compensate for the loss of habitat and produce habitat gains sufficient to approach or exceed pre-project conditions for adults of both species. Adult steelhead appear to be particularly susceptible to reductions in summer and fall IWM due to the potential importance of instream cover for adults that may be holding or migrating upstream. However, the SAM model represents a worst case scenario. Adult fish use the river channel at the project sites as a migration pathway to upstream spawning habitat, and long-term changes in nearshore habitat conditions generally have been expected to have negligible effects on adults because adult Chinook salmon and steelhead generally use deep, mid-channel habitats. Additionally, based on post-project field evaluations of similar projects constructed by the Corps in 2006, the changes do not appear to obstruct or delay the upstream migration of any adult fish and will not affect their ability to successfully reach upstream spawning habitat and reproduce. Therefore, although the model shows a negative response for adult migration, NMFS expects that adult fish are not likely to be injured or killed as a result of the loss of overhead cover, since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

(2) ***Juvenile Rearing and Migration***

Rearing and emigrating juveniles and smolts may occur at the project sites during the fall, winter, and spring. Downstream movement of substantial numbers of juvenile Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and steelhead appears to be triggered by storm events and the resulting high flow and turbidity, with the peak outmigration period for Sacramento River winter-run Chinook salmon typically occurring from November through January, and the period for CV spring-run Chinook salmon occurring from December through May. Juveniles and smolts are most likely to occur at the project sites during their downstream migration to the ocean, which may begin as early as December and peaks from January to May.

The construction of seasonally emergent wetland and riparian floodplain benches, and the retention and/or placement of riparian vegetation, and IWM at all project sites are designed to benefit juvenile Chinook salmon and steelhead by increasing the availability (*i.e.*, habitat area), accessibility (*i.e.*, frequency of inundation), and quality (*i.e.*, shallow water and in stream cover) of nearshore aquatic habitat and SRA habitat relative to current conditions. Because of these design features, the project is expected to provide an overall long-term increase over current conditions in the quantity and quality of estuarine and freshwater rearing sites and migration corridors for juvenile Chinook salmon and steelhead. However, some short- and long-term impacts are expected. During the years and flow conditions where there is a deficit in SAM values, individual fish are expected to be injured or killed by reduced growth conditions and increased predation.

SAM results using the available site designs indicate initial deficits for all species of salmon and steelhead at many sites, followed by recovery and net positive responses at most sites over the modeled 50-year period. Deficits at the fall and summer water surface elevations are most substantial, occurring at every site, and lasting from one to fifty years. Fall and summer deficits persist through year 50 at half of the sites (*i.e.*, Sacramento RMs 44.7R, 47.0L, 47.9R, 48.2R, 62.5R, 68.9L, and 78.0L). Other sites recover between year 5 and 25. Fall and summer deficits are due to the damage or removal of some riparian vegetation and IWM at low bank elevations, and conversion of shallow-water habitat with fine-textured substrate to large angular rock placed at a 2:1 or 3:1 slope. Improving these deficits through design modifications at the fall and summer shorelines is complicated by the desire to minimize the amount of rock placed in the river (*i.e.*, changing the design slope from 2:1 to 10:1 would increase shallow water habitat availability and improve results, but would require placing rock across most of the channel), and the difficulties associated with establishing riparian vegetation at these elevations (*i.e.*, boat wake erosion and high summer flows limit riparian establishment in these zones).

Deficits at winter and spring water surface elevations, are temporary, generally lasting for only a few years. At Sacramento River sites upstream and inclusive of site RM 30.0R, the addition of anchored IWM, the construction of seasonally inundated benches, and the use of soil within and on top of rock would compensate for initial winter and spring losses of juvenile and smolt habitat modeled at many sites, with net increases in winter and spring habitat for these life stages occurring no later than year 5, due to the establishment and growth of riparian vegetation plantings. At Delta sites where IWM would not be added (*i.e.*, Sacramento RM 16.9L and Steamboat Slough RMs 19.0R, 19.4R, and 22.7R) the proposed project would be unable to compensate for these habitat deficits on-site. To help offset this, the Corps will place at least 80 percent shoreline coverage of IWM at sites upstream from, and including RM 33.0R. The credit of this additional IWM was weighed against the negative values anticipated at the Delta sites downstream from RM 30.0, and balanced to a positive effect in the modeling results. As a result, for all sites and seasonal flow elevation combined, the project produces positive SAM results by year 5.

Implementation of the project would result in temporary losses of aquatic and riparian vegetation and IWM along the affected shorelines. These losses would initially reduce year-round habitat value for most salmonid life stages at many sites. However, these cover losses would be concurrent with construction of planted riparian benches at all sites and planted wetland benches at all Steamboat Slough sites (*i.e.*, RM 19.0R, 19.4R, and 22.7R) and at Sacramento River RM 16.9L. The constructed wetland benches are expected to increase the availability of valuable shallow-water rearing habitat for juvenile salmonids, resulting in net increases in habitat for juveniles and smolts at these sites. The density of planted wetland vegetation would minimize the wetland bench area available to large predators such as largemouth bass, and the constructed wetland habitat would therefore not be expected to increase predation.

Over time, the increasing shade value of planted riparian vegetation would result in eventual net increases in juvenile and smolt habitat in winter and spring at all sites, and in summer and fall at some sites. However, at Sacramento RMs 44.7R, 47.0L, 47.9R, 48.2R, 62.5R, 68.9L, and 78.0L, increased riparian shade is not sufficient to compensate for summer and fall reductions in juvenile and smolt cover caused by the permanent losses of IWM and the initial and continued lack of aquatic vegetation.

Anchored IWM, placed on the banks at Sacramento River sites located upstream and inclusive of site RM 30.0R, would result in a net increase in IWM at winter and spring water levels at each placement site. The immediate increase in winter and spring instream structure at these sites contributes to wet season gains in habitat value for all species and life stages present. However, in summer and fall, anchored IWM would not be usable at any site as currently designed because IWM would be placed above the mean summer water line and would therefore, this important structural habitat component would not be inundated during typical summer and fall water surface elevation (*i.e.*, low flows). In summer and fall, when added IWM would be above the mean water line and not available as habitat, initial juvenile and smolt habitat deficits at most sites would reduced by increasing riparian shade.

In summary, habitat impacts will result in reduced growth and survival conditions for juvenile and smolt Chinook salmon and steelhead at fall water surface elevations for the life of the project, and short-term (*i.e.*, 1 to 5 year) deficits, but substantial long-term (*i.e.*, 5 to 50 year) increases above baseline conditions at winter and spring water surface elevations. Despite the modeled summer and fall habitat deficits, they are expected to affect relatively few fish, since the majority of rearing and emigration within the action area does not occur during average fall flow conditions. Instead, a significant majority of Chinook salmon and steelhead rearing and emigration occurs during periods of higher flow that are more accurately represented by average winter and spring water surface elevations. Short-term habitat deficits are expected to cause injury and death of individuals at all sites from reduced growth conditions and increased predation, for 1 to 15 years. Long-term effects at the winter and spring water surface elevations will be substantially positive, with conditions improving beyond existing conditions through year 50.

b. *Long-term Effects of SRBPP Actions on the Southern DPS of North American Green Sturgeon*

(1) *Adult Migration and Holding*

Adult green sturgeon move upstream through the project sites between March and July. Long-term changes in nearshore habitat are expected to have negligible effects on adults because adult sturgeon use deep, mid-channel habitat during migration. The long-term effects of the proposed project related to North American green sturgeon adults would primarily be related to the alteration of the Sacramento River below the waterline as migrating and holding adults utilize benthic habitat. The ecosystem changes from the removal or reduction of riparian vegetation and IWM could affect potential prey items and species interactions that green sturgeon would experience while holding. However, these changes are minimized considerably in the project design and the effects of this riparian and IWM removal or reduction would decrease through time as a result of the proposed projects conservation measures. Therefore, NMFS expects that adult fish are not likely to be injured or killed as a result of the project since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

(2) *Larval, Post-larval, and Juvenile Rearing and Migration*

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile Southern DPS of North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthic (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the removal or reduction of riparian vegetation and IWM likely impacts potential prey items and species interactions that green sturgeon would experience while rearing and migrating. These changes are minimized considerably in the project design and the effects of this riparian and IWM removal or reduction would decrease through time as a result of the proposed projects conservation measures.

In the absence of modeled response data for green sturgeon, NMFS expects responses to long-term, project-related habitat conditions to be similar to juvenile salmonids. Overall, there will be short-term (*i.e.* 5 to 15 year) decreases at winter and spring shorelines, and long-term (*i.e.*, 5 to 50 year) increases over current conditions in the quantity and quality of estuarine and freshwater rearing sites and migration corridors at all project sites. Short-term habitat deficits are expected to cause injury and death of individuals at all sites from reduced growth conditions and increased predation, for 1 to 15 years. Some long-term impacts are expected, primarily along the summer and fall shorelines. At these elevations, initial losses of vegetative cover and IWM are expected to cause injury or death of individuals from reduced growth conditions and increased predation, for the life of the project (*i.e.*, 50 years). Growth and survival conditions at fall flow conditions would recover slightly and stabilize because of increases in the extent of shade along the average fall shoreline, but remain mostly negative through year 50. Because green sturgeon are not as near-shore oriented as juvenile Chinook salmon, the relative proportion of the green sturgeon population that will be affected by these conditions should be low.

c. Long-term Effects of SRBPP Actions on Critical Habitat

The long-term effects of SRBPP actions on the critical habitat of winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead can be measured using the SAM results because they represent indices of fish response to habitat change. The condition of estuarine and freshwater rearing and migration PCEs will be reduced at fall water surface elevations for the life of the project. At spring and winter water surface elevations, these PCEs will be reduced short-term (*i.e.*, 1 to 5 year), but show substantial long-term (*i.e.*, 5 to 50 year) increases above baseline conditions as the integrated habitat features such as shade, and aquatic vegetation become established and developed. Despite the modeled summer and fall habitat deficits, they are not expected to reduce the overall conservation value of rearing and migration PCEs because the majority of rearing and emigration within the action area does not occur during average fall flow conditions. Instead, a significant majority of Chinook salmon and steelhead rearing and emigration occurs during periods of higher flow that are more accurately represented by average winter and spring water surface elevations.

4. <u>Impacts of Project Monitoring</u>

The Corps' final monitoring plan is expected to include direct sampling of juvenile anadromous salmonids to evaluate the effectiveness of integrated project conservation features for protecting Federally listed fish. Other components of the monitoring plan will involve photo documentation, and point estimates of substrate size, IWM, riparian vegetation, and other physical project elements. Non-fishery sampling will be passive and is not expected to have any effect of Federally listed fish or designated critical habitat. Although the details of the monitoring effort are not finalized at the time of writing this biological opinion, fishery monitoring is expected to begin in 2007, and continue for 5 consecutive years, through 2013.

Fishery monitoring involves monthly sampling at selected project locations in the action area throughout the juvenile migration period using boat electrofishing methods. If turbidity is low, passive techniques, including direct underwater observation may be used. NMFS does not expect passive techniques to adversely affect listed fish species or critical habitat. Up to 14 sites may be monitored during periods of no bench inundation, partial bench inundation, and full bench inundation. Sampling will occur once per month throughout the migration and rearing period of juvenile fish in the action area (*i.e.*, November through May). At a maximum each project site is expected to be sampled 6 times per year. However, sampling is expected to rotate through a panel of representative sites, which will reduce the sampling frequency at an individual site. Electrofishing can result in a variety of effects from simple harassment to injury to the fish (adults and juveniles) and death. There are 2 major forms of injuries from electrofishing; hemorrhages in soft tissues and fractures in hard tissues. Electrofishing can also result in trauma to fish from stress (NMFS 2003a). Recovery from this stress can take up to several days, and during this time the fish are more vulnerable to predation, and less able to compete for resources. Stress-related deaths also can occur within minutes or hours of release, with respiratory failure usually the cause. Electrofishing can have severe effects on adult salmonids, particularly spinal injuries from forced muscle contraction. Studies also found dramatic negative effects of electrofishing on the survival of eggs from electroshocked female salmon (NMFS 2003a). The effects of electrofishing are further described in the Central Valley Research Opinion (NMFS 2003a).

Because of the spatial and temporal aspect of the electrofishing effort, both juvenile and adult salmonids can be exposed to the sampling; however, because this effort is completed along the shoreline, the probability of encountering adults is low. In addition, the study sites for electrofishing are not in the vicinity of adult salmonids in spawning condition or near redds. Juveniles are more likely to be exposed to the sampling activities, but the relatively few studies that have been conducted on juvenile salmonids indicate that spinal-injury rates are substantially lower than they are for large fish. Smaller fish intercept a smaller head-to-tail potential than larger fish and may therefore be subject to lower injury rates (*e.g.*, Hollender and Carline 1994, Dalbey *et al.* 1996, Thompson *et al.* 1997). McMichael *et al.* (1998) found a 5.1 percent injury rate for juvenile steelhead captured by electrofishing in the Yakima River sub basin.

One adult Central Valley steelhead and no listed adult Chinook salmon were captured as a result of IEP electrofishing sampling efforts in 1999, 2001, 2002, and 2003. A total of 8 juvenile Sacramento River winter-run Chinook salmon were captured, one of which died. During the same sampling period, a total of 35 juvenile Central Valley spring-run Chinook salmon were captured (10 in 2002, and 25 in 2003), and 10 juvenile Central Valley steelhead were captured with no mortality. McLain and Castillo (2006) captured Chinook salmon fry in the Delta and the lower Sacramento River at rates that generally ranged from less than one, to almost five fish per minute. Most of the captured fish were classified as Central Valley fall-run Chinook salmon (CV fall-run Chinook salmon (*O. tshawytscha*)). McLain (NMFS, pers. comm. 2006) estimates that captures in the mainstem Sacramento River north of Sacramento could be as high as 10 fish per minute, and a majority of the fish likely would be fall-run Chinook salmon. McLain (NMFS, pers. comm. 2006), also estimates that each pass through a bank protection project of 1,000 feet would last about 20 minutes.

Assuming that fish occurs at all 14 sites, up to six times per year, and sampling will last up to 20 minutes per site, with 10 fish captured per minute, a total of 11,780 fish would be captured. Assuming that 95 percent of the captured fish are non-listed CV fall-run Chinook salmon, based on juvenile abundance estimates at Red Bluff Diversion Dam (Gaines and Martin 2002) only 589 fish would be listed salmonids. Assuming an injury rate of 10 percent (a conservative estimate that doubles the level observed by McMichael *et al.* (1998)), 59 listed salmonids may be injured. At a mortality rate of 5 percent (common level reported in the Central Valley), 29 additional juvenile fish would be killed. If the capture, injury, and mortalities are divided equally between Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead (an assumption based on an equal level of effort occurring during the migration period of each species without accounting for fluctuating juvenile population abundance), the monitoring would result in the annual capture of approximately 196 fish, the annual injury of 20 fish, and the annual mortality of 10 fish for each species. These amounts are divided equally Actual levels should be lower because not all sites will be sampled, and river flows and scheduling complexities are likely to reduce the sampling frequency to fewer than six times per year.

The number of fish that will be captured, injured, or killed is expected to be relatively low compared to the overall abundance of juvenile Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. Because sampling will be limited to nearshore areas, and not in adult migration corridors, no more that 1 adult of each species is expected to be captured each year. The anticipated low levels of capture, injury, and mortality are not expected to result in population level impacts. Monitoring results will be used to validate the effectiveness of project conservation measures for avoiding or minimizing adverse impacts of bank protection projects on Federally listed fish species.

5. Impacts to Critical Habitat

Impacts to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead include the short- and long-term modification of approximately 9,817 lf , and 21.7 acres of nearshore aquatic and riparian areas that are designated critical habitat. PCEs at the 14 sites include estuarine and riverine areas for rearing and migration.

The most substantial impacts to these PCEs are at fall and summer low-flow conditions and result from loss of modification of riparian vegetation, IWM, shallow-water habitat, and the increase in bank substrate size. These losses and modifications affect the PCEs by reducing instream cover and food production, and increasing their susceptibility to predation, injury, and death. Impacts to juvenile rearing and migration PCEs during fall and summer will last for the life of the project (*i.e.*, 50 years). Short-term impacts at winter and spring conditions will adversely affect the these PCEs for 1 to 5 years, but from year 5 through year 50, the project's integrated conservation measures will improve the condition of estuarine and freshwater areas for rearing and migration beyond baseline conditions. This improvement is attributable to increases in the amount of IWM, SRA cover, shade, and seasonally-inundated shallow-water habitat, all of which contribute to positively to the growth and survival of fish using the habitat.

6. Interrelated or Interdependent Actions

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). NMFS considered concurrent, ongoing repair of an additional 57 levee repair projects in the SRFCP as potentially interrelated or interdependent actions in the action. These projects are expected to result in effects to listed salmon, steelhead, and sturgeon that are similar to those previously described in this biological opinion for the proposed action, including short-term adverse effects to these species and their designated critical habitat. NMFS does not consider these actions to be interrelated because there is no single authority or program that binds them together, or interdependent because they would occur regardless of the proposed action.

VI. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Cumulative effects include non-Federal riprap projects. Depending on the scope of the action, some non-Federal riprap projects carried out by State or local agencies do not require Federal permits. These types of actions, and illegal placement of non-Federal riprap are common throughout the action area. The effects of such actions result in continued fragmentation of existing high-quality habitat, and conversion of complex nearshore aquatic to simplified habitats that affect salmonids in ways similar to the adverse effects associated with the proposed action. Reasonably certain cumulative effects may include any continuing or future non-Federal water diversions. Water diversions through intakes serving numerous small, private agricultural lands and duck clubs along the lower Sacramento River contribute to these cumulative effects. These diversions also include municipal and industrial uses as well as water for power plants. Water diversions affect salmonids and sturgeon by entraining, and injuring or killing adult or juvenile fish.

Additional cumulative effects may result from the discharge of point and non-point source chemical contaminant discharges. These contaminants include selenium and numerous pesticides and herbicides associated with discharges related to agricultural and urban activities. Contaminants may injure or kill salmonids by affecting food availability, growth rate, susceptibility to disease, or other physiological processes necessary for survival.

VII. INTEGRATION AND SYNTHESIS

A. Impacts of the Proposed Action on Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, Central Valley Steelhead

NMFS expects that the proposed action will result in adverse short-term, construction-related impacts, O&M-related impacts, habitat impacts, and monitoring impacts that will capture, injure, and kill Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead. Phase 1 construction-related effects are expected to affect juveniles. Juveniles are expected to be affected because of their small size, reliance on nearshore aquatic habitat, and vulnerability to factors that injure or kill them, or otherwise affect their growth and survival, such as noise or crushing of fish from rock placement and barge activity, changes in water quality that temporarily modify their natural behavior and may reduce their growth or expose them to predation.

Phase 1 construction impacts to juveniles occur within approximately 9,817 lf of aquatic habitat along the banks of the Sacramento River and Steamboat Slough, are expected to impact juveniles from November 13, 2006 through June 1, 2007. Although construction will occur during peak migration periods, relatively few juvenile fish are expected to be injured or killed by in-river construction activities because most fish are expected to avoid construction activities due to their predominately crepuscular migration behaviors, and most of those that are exposed to construction are expected to detect project-related disturbance and noise and avoid being injured or killed. The implementation of BMPs and other on-site measures also will minimize impacts to the aquatic environment and reduce project-related effects to fish. Furthermore, only one cohort, or emigrating year class, out of perhaps four to five within each population will be affected. Therefore, NMFS expects that actual injury and mortality levels will be low relative to the overall population abundance, and not likely to result in any long-term, negative population trends. Adults should not be injured because their size, preference for deep water, and crepuscular migratory behavior enable them to avoid temporary, nearshore disturbance.

O&M impacts will occur for the life of the project and primarily will be caused by infrequent in-water construction and rock placement necessary to maintain the project in functional condition. O&M activities are expected to occur between July 1 and November 30 for the life of the project (*i.e.*, 50 years). Individuals are expected to be injured or killed during the month of November from turbidity-induced predation during the annual placement of the bank protection material of no more than 600 cubic yards of material. Relatively few fish are expected to be injured or killed by O&M activities because the majority of construction will occur before high flows trigger peak migration, and because the implementation of BMPs and other on-site measures are expected to minimize impacts to the aquatic environment.

Long-term effects as modeled by the SAM will result in reduced adult migration conditions, and reduced growth and survival conditions for juvenile and smolt Chinook salmon and steelhead at summer and fall water surface elevations for the life of the project. At winter and spring water surface elevations, short-term (*i.e.*, 1 to 5 year) deficits, but substantial long-term (*i.e.*, 5 to 50 year) increases above baseline conditions will occur. The modeled summer and fall habitat deficits are expected to affect relatively few fish, since the majority of adult migration and juvenile rearing and emigration within the action area does not occur during average fall flow conditions. Instead, a significant majority of Chinook salmon and steelhead adult migration and juvenile rearing and emigration occurs during periods of higher flow that are more accurately represented by conditions at average winter and spring water surface elevations. Short-term habitat deficits at winter and spring water surface elevations are expected to cause injury and death of individuals at all sites from reduced growth conditions and increased predation, for 1 to 15 years. Long-term effects at the winter and spring water surface elevations will be substantially positive, with conditions improving beyond existing conditions through year 50.

The long-term SAM-modeled deficits to adult migration conditions represent a worst case scenario. Adult fish use the river channel at the project sites as a migration pathway to upstream spawning habitat, and long-term changes in nearshore habitat conditions generally have been expected to have negligible effects on adults because adult Chinook salmon, and steelhead generally use deep, mid-channel habitats. Although some fish may be harmed, and injured or killed as a result of the loss of overhead cover, the number of fish should be low since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

Fishery monitoring will capture, injure, and kill juvenile and adult anadromous fish for five years, until 2013. Fish will be captured, injured, and killed from fish sampling for this period between the months of November and May. NMFS expects that fewer than 10 percent of fish captured will be injured, and fewer than 5 percent will be killed. No more than an annual capture of 580 juvenile fish, including an annual injury of 58 fish, and an annual mortality of 29 fish is expected for each Federally listed anadromous salmonid ESU or DPS.

B. Impacts of the Proposed Action on the Southern DPS of North American Green Sturgeon

NMFS also expects the action to adversely affect the Federally listed Southern DPS of the North American green sturgeon. Adverse effect to these species is expected to be limited to migrating and rearing larvae, post-larvae, juveniles and holding adults. Juveniles are expected to be affected most significantly because of their small size, reliance on aquatic food supply (allochthonous food production), and vulnerability to factors that affect their feeding success and survival. Construction activities will cause disruptions from increased noise, turbidity, and inwater disturbance that may injure or kill larvae, post-larvae, and juveniles by causing reduced growth and survival as well as increased susceptibility to predation. Adverse affects to adults are primarily limited to the alteration of habitat below the waterline affecting predator prey relationships and feeding success. As is the case for salmonids, the habitat and species-level impacts that are expected at certain sites will result in substantial long-term gains in nearshore and riparian health offering benefits to larvae, post-larvae, juvenile, and adult Southern DPS of North American green sturgeon.

C. Impacts of the Proposed Action on the Survival and Recovery of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead

The adverse effects to Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead within the action area are not expected to affect the likelihood of survival and recovery of the ESUs. This is largely due to the fact that the project will compensate for temporary and permanent habitat losses of habitat through implementation of on-site and off-site conservation measures. Most construction-related impacts will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or juvenile fish from migrating to downstream rearing areas. The number of individuals actually injured or killed by construction and O&M activities is expected to be small because only fish that are present during the month of November are expected to be affected. Similarly, the number of fish that will be injured or killed as a result of short-and long-term habitat impacts, as indexed by the SAM will be low because the primary loss of habitat condition and function is limited to the low-flow fall water surface elevations, while the majority of juvenile fish are expected to be present during winter and spring months, when seasonal water elevations are higher, and integrated conservation measures such as riparian vegetation, overhanging shade, IWM and engineered benches are inundated and available to the species. Although Federally listed anadromous fish may be present in the action area during the fall months, abundance is relatively low compared to the number of fish that are present during winter months.

Fishery monitoring will capture, injure, and kill juvenile and adult anadromous fish for five years, until 2012. No more than an annual capture of 196 juvenile fish, an annual injury of 20 fish, and an annual mortality of 10 fish is expected for each Federally listed anadromous salmonid ESU or DPS. These rates are not significant compared to the overall abundance of the species, and are not expected to reduce the likelihood of the survival and recovery of Federally listed anadromous salmonids in the action area. Furthermore, monitoring will ensure that project conservation measures are functioning to benefit the species. If monitoring shows that project features are limiting the growth and survival of fish in the action area, then those features will be modified or discontinued. If monitoring shows features that are beneficial, they will continue to be maintained and applied to future projects. Monitoring is an essential component for ensuring that the overall action of stabilizing the levee system does not reduce the likelihood of the species survival and recovery in the action area.

Without the integration of on- and off-site conservation measures, including re-establishing riparian vegetation, IWM, and constructing seasonally inundated shallow-water benches, the adverse effects on the PCEs of Sacramento River winter-run Chinook salmon, Central Valley steelhead and Central Valley spring-run Chinook salmon habitat would significantly reduce the conservation value of their designated critical, and would reduce the ability for these fish to survive and recover in the action area.

In addition to the factors affecting the species in the action area in the *Environmental Baseline* section of this biological opinion, which currently are addressing and reducing juvenile entrainment at water diversions and habitat loss from channel operation maintenance, the proposed action has specifically been designed to minimize and avoid continued nearshore aquatic and riparian habitat loss from large-scale bank protection projects. The proposed implementation of the integrated conservation measures will ensure that short- and long-term impacts associated with these bank protection projects will be compensated in a way that prevents incremental habitat fragmentation, and loss area. Although some injury or death to individual fish is expected from construction activities, O&M, and short- and long-term habitat modification, successful implementation of all conservation measures is expected to improve migration and rearing conditions, and the growth and survival of juvenile salmon and steelhead during peak rearing and migration periods by protecting, restoring, and in many cases, increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area. Because of this, the proposed action is not expected to reduce the likelihood of survival and recovery of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead within the action area.

D. Impacts of the Proposed Action on the Survival and Recovery of the Southern DPS of North American Green Sturgeon

The adverse effects to Southern DPS of North American green sturgeon within the action area are not expected to affect the overall survival and recovery of the DPS. This is largely due to the fact that the project will compensate for temporary and permanent habitat losses of habitat through implementation of on-site and off-site conservation measures. Construction-related impacts will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or larvae, post-larvae, and juvenile fish from rearing or migrating to downstream rearing areas. The number of individuals actually injured or killed is expected to be undetectable and negligible and, population-level impacts are not anticipated. Implementation of the conservation measures will ensure that long-term impacts associated with bank protection projects will be compensated in a way that prevents incremental habitat fragmentation, and reductions of the conservation value of aquatic habitat to anadromous fish within the action area. Because of this, the proposed action is not expected to reduce the likelihood of survival and recovery of the Southern DPS of North American green sturgeon within the action area.

E. Impacts of the Proposed Action on Critical Habitat

Impacts to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead include the short- and long-term modification of approximately 9,817 lf , and 21.7 acres of nearshore aquatic and riparian areas that are designated critical habitat. PCEs at the 14 sites include estuarine and riverine areas for rearing and migration. NMFS CHART (2005b) described existing PCEs within the action area as degraded, with isolated fragments of high quality habitat. In spite of the degraded condition, the CHART report rated the conservation value of the action area as high because if is used as a rearing and migration corridor for all populations of winter-run Chinook salmon and CV spring-run Chinook salmon, and by the largest populations of CV steelhead.

The primary project-related impacts to PCEs are at fall and summer low-flow conditions and result from loss of modification of riparian vegetation, IWM, shallow-water habitat, and the increase in bank substrate size. These losses and modifications affect the PCEs by reducing instream cover and food production, and increasing their susceptibility to predation, injury, and death. Impacts to juvenile rearing and migration PCEs during fall and summer will last for the life of the project (*i.e.*, 50 years). Short-term impacts at winter and spring conditions will adversely affect the these PCEs for 1 to 5 years, but from year 5 through year 50, the project's integrated conservation measures will improve the condition of estuarine and freshwater areas for rearing and migration beyond baseline conditions. This improvement is attributable to increases in the amount of IWM, SRA cover, shade, and seasonally-inundated shallow-water habitat, all of which contribute to positively to the growth and survival of fish using the habitat. The adverse effects to PCEs at summer and fall flows are expected to affect relatively few fish, since the majority of the juvenile rearing and emigration within the action area occurs during periods of higher flow that are more accurately represented by conditions at average winter and spring water surface elevations. The improved conditions are expected to improve the growth and survival conditions for juvenile fish. Therefore, we do not expect project-related impacts to reduce the conservation value of designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of Central Valley spring-run Chinook salmon, and Central Valley steelhead, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the SRBPP 14 Critical Levee Erosion Repairs, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead, and is not likely to destroy or adversely modify their designated critical habitat.

After reviewing the best available scientific and commercial information, the current status of the Southern DPS of North American green sturgeon, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the SRBPP 14 Critical Levee Erosion Repairs, as proposed, is not likely to jeopardize the continued existence of the Southern DPS of the North American green sturgeon.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The listing of the Southern DPS of North American green sturgeon became effective on July 7, 2006, and some or all of the ESA section 9(a) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). Because there are no section 9(a) prohibitions at this time, the incidental take statement, as it pertains to the Southern DPS of North American green sturgeon does not become effective until the issuance of a final 4(d) regulation.

The measures described below are non-discretionary, and must be undertaken by the Corps so that they become binding conditions of any grant or permit, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps: (1) fails to assume and implement the terms and conditions, or (2) fails to require the contractors to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impact on the species to NMFS as specified in the incidental take statement (50 CFR §402.14(i)(3)).

A. Amount and Extent of Take

NMFS anticipates incidental take of Sacramento River winter-run Chinook salmon, Central Valley steelhead, Central Valley spring-run Chinook salmon, and the Southern DPS of North American green sturgeon from impacts related to construction, O&M, and through long-term impairment of essential behavior patterns as a result of reductions in the quality or quantity of their habitat. Take is expected to be limited to rearing and smolting juveniles.

NMFS cannot, using the best available information, quantify the anticipated incidental take of individual Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. However, it is possible to describe the conditions that will lead to the take.

Accordingly, NMFS is quantifying take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon incidental to the action in terms associated with the extent and duration of initial construction and O&M activities, and long-term impacts as indexed by the SAM model. The following level of incidental take from project activities is anticipated:

1. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon in the form of injury and death from predation caused by constructed-related turbidity that extends up to 100 feet from the shoreline, and 1,000 feet downstream, along all project reaches for construction that occurs from November 13, 2006 to June 1, 2007.

2. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon, in the form of harm or injury of fish from O&M actions is expected from habitat-related disturbances from the annual placement of up to 600 cubic yards of material per site for the extent of the project life (*i.e.*, 50 years). Take will be in the form of harm to the species through modification or degradation of juvenile rearing and migration habitat.

3. Take in the form of harm of adult Chinook salmon, steelhead, and green sturgeon at fall and summer water surface elevations at all sites from the loss of overhead cover along 9,817 lf of nearshore habitat for 50 years, as represented by the SAM results shown in Appendix B, Tables 1-32 through 1-45, or as represented by any future improved SAM results that show differently.

4. Take in the form of harm, injury, and death of rearing and smolting Chinook salmon, steelhead, at fall and summer water surface elevations from the modification of 6,910 lf of nearshore habitat that adversely affects the quality and quantity of juvenile Chinook salmon, steelhead, and green sturgeon habitat at Sacramento RMs 44.7R, 47.0L, 47.9R, 48.2R, 62.5R, 68.9L, and 78.0L for 50 years, as represented by the SAM results shown in Appendix B, Tables 1-39 through 1-45, or as represented by any future improved SAM results that show differently.

5. Take in the form of harm, injury, and death of rearing and smolting Chinook salmon, steelhead, at fall and summer water surface elevations from the modification of 2,907 lf of nearshore habitat that adversely affects the quality and quantity of juvenile Chinook salmon, steelhead, and green sturgeon habitat at Sacramento RMs 16.9L, 33.0R, 33.3R, and 43.7R, and Steamboat Slough RMs 19.0R, 19.4R, and 22.7R for 1 to 15 years, as represented by the SAM results shown in Appendix B, Tables 1-32 through 1-38, or as represented by any future improved SAM results that show differently.

6. Take in the form of capture from monitoring activities is not expected to exceed an annual amount 196 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the form of injury is not expected to exceed an annual amount of 20 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the

form of death from monitoring activities is not expected to exceed an annual amount of 10 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the form of capture, injury, or death is not expected to exceed one adult fish for each for Federally listed anadromous salmonid ESU of DPS.

Anticipated incidental take may be exceeded if project activities exceed the criteria described above, if the project is not implemented as described in the BA prepared for this project, or if the project is not implemented in compliance with the terms and conditions of this incidental take statement.

B. Effect of the Take

NMFS has determined that the above level of take is not likely to jeopardize Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, or the Southern DPS of North American green sturgeon. The effect of this action in the proposed project areas will consist of fish behavior modification, temporary loss of habitat value, and potential death or injury of juvenile Sacramento River winter-run Chinook salmon, Central Valley steelhead, and Central Valley spring-run Chinook salmon, and the Southern DPS of North American green sturgeon.

C. Reasonable and Prudent Measures

NMFS has determined that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of listed anadromous salmonids.

1. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

2. Measures shall be taken to minimize the impacts of bank protection by implementing integrated onsite and offsite conservation measures that provide beneficial growth and survival conditions for juvenile salmonids, and the Southern DPS of North American green sturgeon.

D. Terms and Conditions

1. Measure shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

    a. The Corps shall continue to coordinate with the IWG agencies and the Technical Team of the Interagency Collaborative Flood Management Program to finalize the development of Phase II designs.

b. The Corps shall make every reasonable effort necessary to ensure that Phase II construction minimizes the loss of existing riparian vegetation and allows for the establishment of riparian vegetation at all seasonal water surface elevations within the project footprint.

c. The Corps shall provide a project summary and compliance report to NMFS within 60 days of completion of construction. This report shall describe construction dates, implementation of project conservation measures, and the terms and conditions of the final biological opinion; observed or other known effects on the Sacramento River winter-run Chinook salmon, if any; and any occurrences of incidental take of the Sacramento River winter-run Chinook salmon, Central Valley steelhead, and Central Valley spring-run Chinook salmon.

d. The Corps shall provide a second project summary and compliance report to NMFS within 12 months of the issuance of the final biological opinion. This report shall provide a progress update on implementation of the outstanding off-site conservation measures; and details on the off-site location, and project design development for the off-site conservation requirements.

e. The Corps shall provide additional annual reports, as necessary, to describe the implementation of off-site conservation measures, to summarize O&M actions, and summarize monitoring results.

f. The Corps shall continue to coordinate the implementation of project-specific monitoring as described in *section II, Description of the Proposed Action*, with the IWG agencies.

g. The Corps shall increase the duration of project-specific monitoring from 5 to 10 years. NMFS does not expect that all sites will require 10 years of monitoring. Instead, through ongoing cooperation with the IWG agencies, a select, representative group of project sites will be monitored for this period.

h. The Corps shall complete a final project-specific monitoring plan, in cooperation with the IWG agencies, and with NMFS approval, within 90 days of the issuance of the final biological opinion. Once approved, this monitoring plan must be incorporated into the O&M manual. Development of this monitoring plan must be done in coordination with NMFS and the IWG agencies, and must meet the approval of NMFS before being finalized. The project-level monitoring may be combined with program-level monitoring once the Corps completes a comprehensive monitoring plan. The purpose of the monitoring is to confirm that the project was implemented as proposed, and to validate that proposed project conservation measures effectively avoid and minimize adverse effects to Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon.

i. The Corps shall complete a draft comprehensive aquatic and riparian monitoring plan, in cooperation with the IWG agencies, and with NMFS approval, within 120 days, and a final plan within 180 days of the issuance of the final biological opinion. Development of this monitoring plan must be done in coordination with NMFS and the IWG agencies; must rely on the expertise of biologists, fluvial geomorphologists, statisticians, and other experts in developing aquatic monitoring plans or programs; and must meet the approval of NMFS before being finalized. The purpose of the comprehensive monitoring is ensure that integrated conservation measures are implemented as proposed, and are within the range modeled in the SAM analysis and analyzed in NMFS biological opinion; are effective for avoiding, minimizing, or enhancing habitat value for listed fish; and to validate the assumptions inherent to the SAM model. Monitoring also will be used to develop future avoidance, minimization, and enhancement measures.

   Monitoring the effectiveness of the measures installed to meet SAM values may require scientific inquiry that extends beyond in-stream data collection. Tools such as computer modeling and hydraulic models as well as tagging studies should be used as necessary to assess the relative value of each element of the SAM model. In-stream studies must include sampling procedures to determine species composition and abundance together with physical observations and measurements at selected construction and control sites.

j. The Corps shall, in cooperation with the IWG agencies, develop a Riparian Vegetation and IWM Survey, Protection, and Compensation Guidance Manual within 90 days of the issuance of the final biological opinion. The purpose of this manual is to ensure that riparian vegetation and IWM protection and compensation strategies effectively minimized adverse effects to listed fish. At a minimum the manual shall include field survey protocols, construction practices for minimizing impacts to riparian vegetation and existing IWM during bank protection activities, and guidance on the selection, transport, placement, anchoring, and maintenance of IWM. The Riparian Vegetation and IWM Survey, Protection, and Compensation Guidance Manual shall be completed within 6 months of the issuance of the final biological opinion.

k. The Corps shall ensure that future maintenance actions that repair the bank protection structure fully replace conservation features including benches, soil, riparian vegetation, and IWM.

l. The Corps shall update the SAM to include the Southern DPS of North American green sturgeon. The purpose for this update is to ensure that project designs effectively account for, and avoid or minimize potential adverse effects to green sturgeon and their habitat.

m. The Corps shall in cooperation with the IWG agencies, and other appropriate flood control agencies and experts, as deemed necessary, consider conducting a re-evaluation of the SAM to determine, at a minimum, if recent modifications adopted for the evaluation of the critical sites should be adopted into the overall assessment framework. Application of the SAM to recent bank protection projects in the Sacramento River and Lower American River has resulted in several technical and procedural modifications that are currently being applied to improve the SAM's accuracy and precision in quantifying species impacts and benefits associated with specific project features. Additional modifications may be warranted to improve the utility of the SAM during the planning, design, and evaluation phases of future projects.

2. Measures shall be taken to minimize the impacts of bank protection by implementing integrated onsite and offsite conservation measures that provide beneficial growth and survival conditions for juvenile salmonids.

   a. The Corps shall ensure that to the maximum extent practicable, Phase 2 conservation measures are constructed at elevations that maximize seasonal inundation rates, and corresponding availability to anadromous fish, while maintaining bank protection integrity, and promoting the establishment of riparian vegetation suitable for the site.

   b. The Corps shall minimize the removal of existing riparian vegetation and IWM to the maximum extent practicable, and that where appropriate, removed IWM will be anchored back into place. NMFS shall be contacted prior to the removal of any tree greater the 4 inches dbh.

   c. The Corps shall, in consultation with the IWG, ensure to the maximum extent practicable, and without adversely affecting engineering and flood protection integrity of the project, that measures are taken in Phase 2 to expand the diversity of the restricted vegetation plan to include a diverse assemblage of riparian grasses, shrubs, and small trees, including, but not limited to buttonbrush, box elder, white alders, and additional willow species.

d. The Corps shall ensure to the maximum extent practicable, and without adversely affecting engineering and flood protection integrity of the project, or the safety of the public, that measures are taken in Phase 2 to install IWM to achieve at least 40 percent shoreline coverage along the summer and fall bank elevations at all sites upstream and including Sacramento RM 30.0. These features are necessary to minimize long-term (*i.e.*, 15 to 50 year) deficits that affect adult cover, and juvenile growth and survival during low-flow conditions.

e. The Corps shall apply any surplus SAM values generated by this project as compensation for conducting Phase 1 construction during peak salmonid migration periods.

f. The Corps shall ensure to the maximum extent practicable, and without adversely affecting engineering and flood protection integrity, or the growth and survival of existing vegetation, that measures are taken during Phase 2 to integrate soil into project sites by using means that are determined to be feasible and appropriate.

g. The Corps shall conduct an updated SAM assessment of all sites upon completion of Phase 2. If this assessment shows uncompensated habitat deficits, the Corps must prove a compensation strategy to NMFS within 3 months, and any necessary additional compensation must be completed within 12 months.

Reports and notifications required by these terms and conditions shall be submitted to:

Sacramento Area Office
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento California 95814-4706
FAX: (916) 930-3629
Phone: (916) 930-3600

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. These conservation recommendations include discretionary measures that the Corps can implement to avoid or minimize adverse effects of a proposed action on a listed species or critical habitat or regarding the development of information. NMFS provides the following conservation recommendations that would avoid or reduce adverse impacts to listed salmonids:

1. The Corps, under the authority of section 7(a)(1) of the Act, should implement recovery and recovery plan-based actions within and outside of traditional flood damage reduction projects. Such actions may include, but are not necessarily limited to restoring natural river function and floodplain development.

2. The Corps should prepare a Supplemental EIS/EIR for the SRBPP that acknowledges the listing of five fish species since 1987 as significant and discloses to the public and resource agencies the detrimental, ecosystem-scale effects of riprapping, as described in USFWS (2000).

3. The Corps should continue to focus on retaining, restoring and creating river riparian corridors in the recovery of the listed salmonid species within their flood control plan.

4. The Corps should make set-back levees integral components of the Corp's authorized bank protection or ecosystem restoration efforts.

5. The Corps should make more effective use of ecosystem restoration programs, such as those found in Sections 1135 and 206 of the respective Water Resource Developments Acts of 1986 and 1996. The section 1135 program seems especially applicable as the depressed baselines of the Sacramento River winter-run Chinook salmon, Central Valley steelhead, and Central Valley spring-run Chinook salmon are, to an appreciable extent, the result of the Corps' SRBPP program.

6. The PL 84-99 authority should not be used to apply rock revetment to sites where only earthen banks existed previously or which suffer from design flaws not related to erosion.

7. The Corps should incorporate the costs of conducting lengthy planning efforts, involved consultations, implementation of proven off-site conservation measures, and maintenance and monitoring requirements associated with riprapping into each project's cost-benefit analysis such that the economic benefits of set-back levees are more accurately expressed to the public and regulatory agencies. This includes a recognition of the economic value of salmonids as a commercial and sport fishing resource.

8. The Corps should conduct or fund studies to identify set-back levee opportunities, at locations where the existing levees are in need of repair or not, where set-back levees could be built now, under the SRBPP, or other appropriate Corps authority. Removal of the existing riprap from the abandoned levee should be investigated in restored sites and anywhere removal does not compromise flood safety.

9. The Corps should begin early intervention bank protection efforts using set-back levees, and biotechnical approaches, which may then preclude later having to use rock fill and/or rock riprap to achieve engineering goals.

10. As recommended in the NMFS Proposed Recovery Plan for the Sacramento River winter-run Chinook Salmon (NMFS 1997), the Corps should preserve and restore riparian habitat and meander belts along the Delta with the following actions: (1) avoid any loss or additional fragmentation of riparian habitat in acreage, lineal coverage, or habitat value, and provide in-kind mitigation when such losses are unavoidable (*e.g.*, create meander belts along the Sacramento River by levee set-backs), (2) assess riparian habitat along the Sacramento River from Keswick Dam to Chipps island and along Delta waterways within the rearing and migratory corridor of juvenile winter-run Chinook salmon, (3) develop and implement a Sacramento River and Delta Riparian Habitat Restoration and Management Plan (*e.g.*, restore marshlands within the Delta and Suisun Bay), and (4) amend the Sacramento River Flood Control and SRBPP to recognize and ensure the protection of riparian habitat values for fish and wildlife (*e.g.*, develop and implement alternative levee maintenance practices).

11. Section 404 authorities should be used more effectively to prevent the unauthorized application of riprap by private entities.

To be kept informed of actions minimizing or avoiding adverse effects, or benefiting listed or special status species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the SRBPP 14 Critical Levee Erosion Repairs. Reinitiation of formal consultation is required if: (1) the amount or extent of taking specified in any incidental take statement is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the action, including the avoidance, minimization, and compensation measures listed in the *Description of the Proposed Action* section is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion; or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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Enclosure 2

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

Agency:	United States Army Corps of Engineers Sacramento District
Activity:	Sacramento River Bank Protection Project, 14 Critical Levee Erosion Repairs
Consultation Conducted By:	Southwest Region, National Marine Fisheries Service
File Number:	151422SWR2005SA00115
Date Issued:	

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

This document represents the National Marine Fisheries Service's (NMFS) Essential Fish Habitat (EFH) consultation based on our review of information provided by the U.S. Army Corps of Engineers (Corps) on the proposed Sacramento River Bank Protection Project (SRBPP) 14 Critical Levee Erosion Repairs. The Magnuson-Stevens Fishery Conservation Act (MSA) as amended (U.S.C 180 et seq.) requires that EFH be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NMFS on activities which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies. The geographic extent of freshwater EFH for Pacific salmon in the Sacramento River includes waters currently or historically accessible to salmon within the Sacramento River and Steamboat Slough.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle.

The biological opinion for the SRBPP 14 Critical Levee Erosion Repairs addresses Chinook salmon listed under the both the Endangered Species Act (ESA) and the MSA that potentially will be affected by the proposed action. These salmon include Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), and Central Valley spring-run Chinook salmon (*O. tshawytscha).* This EFH consultation will concentrate on Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) because they are covered under the MSA but not listed under the ESA.

Historically, Central Valley fall-run Chinook salmon generally spawned in the Central Valley and lower-foothill reaches up to an elevation of approximately 1,000 feet. Much of the historical fall-run spawning habitat was located below existing dam sites and the run therefore was not as severely affected by water projects as other runs in the Central Valley.

Although fall-run Chinook salmon abundance is relatively high, several factors continue to affect habitat conditions in the Sacramento River, including loss of fish to unscreened agricultural diversions, predation by warm-water fish species, lack of rearing habitat, regulated river flows, high water temperatures, and reversed flows in the Delta that draw juveniles into State and Federal water project pumps.

A. Life History and Habitat Requirements

Central Valley fall-run Chinook salmon enter the Sacramento River from July through December, and late fall-run enter between October and March. Fall-run Chinook salmon generally spawn from October through December, and late fall-run fish spawn from January to April. The physical characteristics of Chinook salmon spawning beds vary considerably. Chinook salmon will spawn in water that ranges from a few centimeters to several meters deep provided that the there is suitable sub-gravel flow (Healey 1991). Spawning typically occurs in gravel beds that are located in marginally swift riffles, runs and pool tails with water depths exceeding one foot and velocities ranging from one to 3.5 feet per second. Preferred spawning substrate is clean loose gravel ranging from one to four inches in diameter with less that 5 percent fines (Reiser and Bjornn 1979).

Fall-run Chinook salmon eggs incubate between October and March, and juvenile rearing and smolt emigration occur from January through June (Reynolds *et al.* 1993). Shortly after emergence, most fry disperse downstream towards the Sacramento-San Joaquin Delta and estuary while finding refuge in shallow waters with bank cover formed by tree roots, logs, and submerged or overhead vegetation (Kjelson *et al.* 1982). These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Smolts generally spend a very short time in the Delta and estuary before entry into the ocean.

II. PROPOSED ACTION.

The Corps and the Reclamation Board propose to implement levee erosion protection at 14 sites in the Sacramento River and Steamboat Slough. The proposed action is described in the *Description of the Proposed Action* section of the preceding biological opinion (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on Pacific Coast salmon EFH would be similar to those discussed in the *Effects of the Proposed Action* section of the preceding biological opinion (Enclosure 1) for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, and threatened Central Valley steelhead. A summary of the effects of the proposed action on Central Valley fall-/late fall-run Chinook salmon are discussed below.

Adverse effects to Chinook salmon habitat will result from construction related impacts, operations and maintenance impacts, and long-term impacts related to modification of aquatic and riparian habitat at the 14 project sites. Primary construction related impacts include riprapping approximately 9,817 lf of riverbank. Integrated conservation measures to minimize adverse effects of riprapping will be applied to all sites. Conservation measures include construction of seasonally inundated terraces that will be planted with riparian vegetation. Instream woody material (IWM) will be placed both below and above the mean summer water surface elevatation (MSW) to provide habitat complexity, refugia, and food production of juvenile anadromous fish.

In-channel construction activities such as vegetation removal, grouting, and rock placement will cause increased levels of turbidity. Turbidity will be minimized by implementing the proposed conservation measures such as implementation of BMPs and adherence to Regional Board water quality standards. Fuel spills or use of toxic compounds during project construction could release toxic contaminants into the Sacramento River. Adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak.

The effects of O&M actions will be similar to construction impacts. The Corps expects to place no more than 600 tons of rock annually. Most actions are expected to occur during the summer when anadromous fish are not expected to be present. Additionally, since O&M actions will not occur every year, and actions will be specific and localized in nature, O&M impacts will be smaller and shorter in duration.

At some sites, there will be short and long-term losses of habitat value. Long-term impacts are expected to adversely affect EFH for adult salmon at average fall and summer water surface elevation for the life of the project. However, at winter and spring water surface elevations, adverse effects to EFH will be short-term, lasting from 1 to 5 years. Long-term effects of the project (*i.e.*, 5 to 50 years) will be positive as riparian habitat becomes mature. Overall, the action will result in a net increase in habitat conditions for Chinook salmon that essential to their survival and growth, especially at winter and spring flows when the majority of fish are outmigrating through the action area. This net increase is expected to maintain and improve the conservation value of the habitat for Chinook salmon and avoid habitat fragmentation that typically is associated with riprapping.

IV. CONCLUSION

Upon review of the effects of SRBPP Critical Levee Erosion Repair project, NMFS believes that the project will result in adverse effects to the EFH of Pacific salmon protected under the MSA.

V. EFH CONSERVATION RECOMMENDATIONS

Considering that the habitat requirements of fall-run within the action area are similar to the Federally listed species addressed in the preceding biological opinion (Enclosure 1), NMFS recommends that Terms and Condition 1a through 1k, and 1h; and 2a through 2d, and 2f and 2g, as well as all the Conservation Recommendations in the preceding biological opinion prepared for the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead ESUs be adopted as EFF Conservation Recommendations.

Section 305(b)4(B) of the MSA requires the Corps to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR ' 600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

VI. LITERATURE CITED

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Appendix A

Project location map,
Conceptual project cross-sections,
and
Aerial photographs of project footprints

From:
Corps 2006, Environmental Assessment for Levee Repair of 14 Winter 2006 Critical Sites, Sacramento River Bank Protection Project

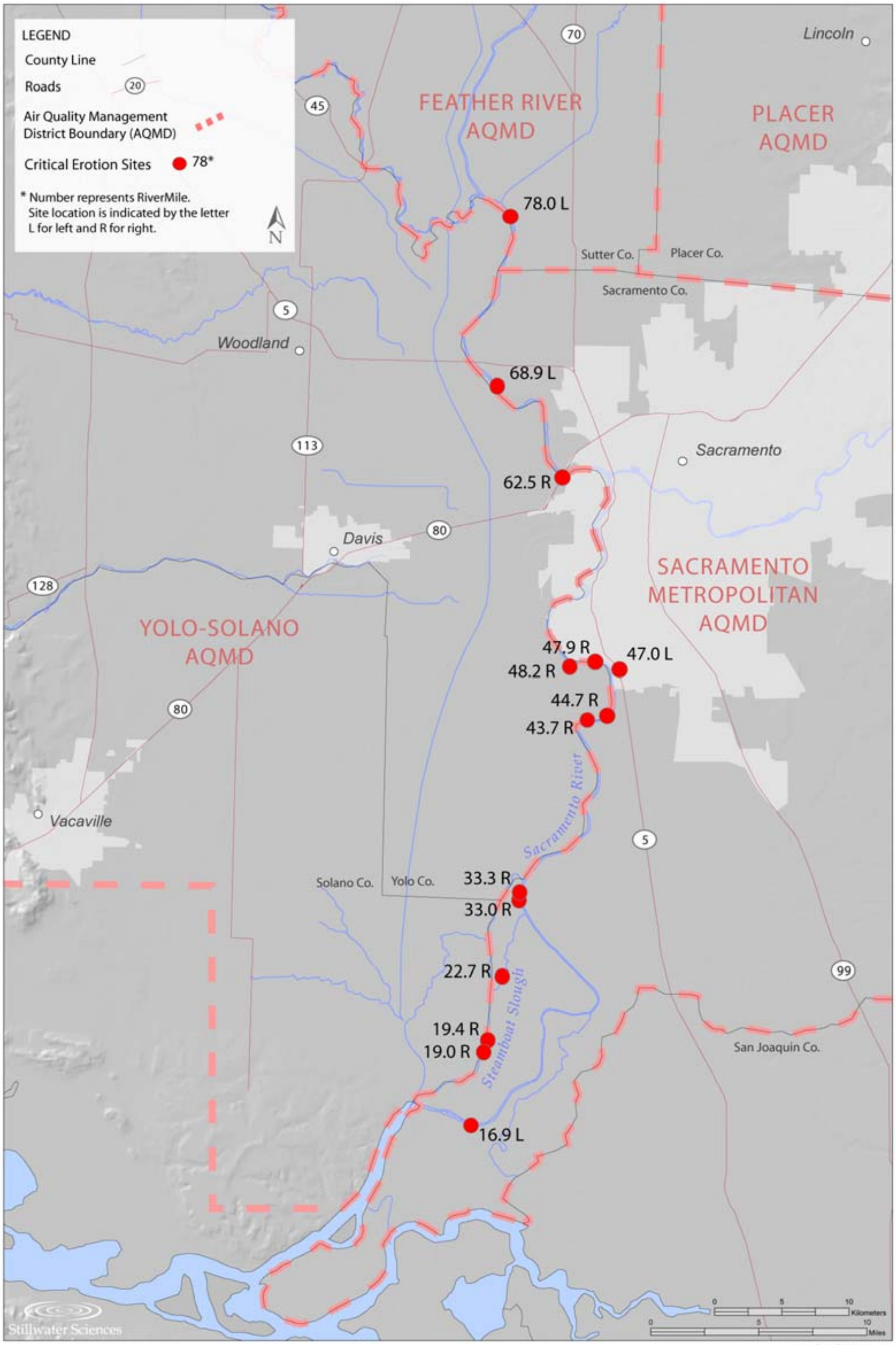

Figure 1. Project location map.

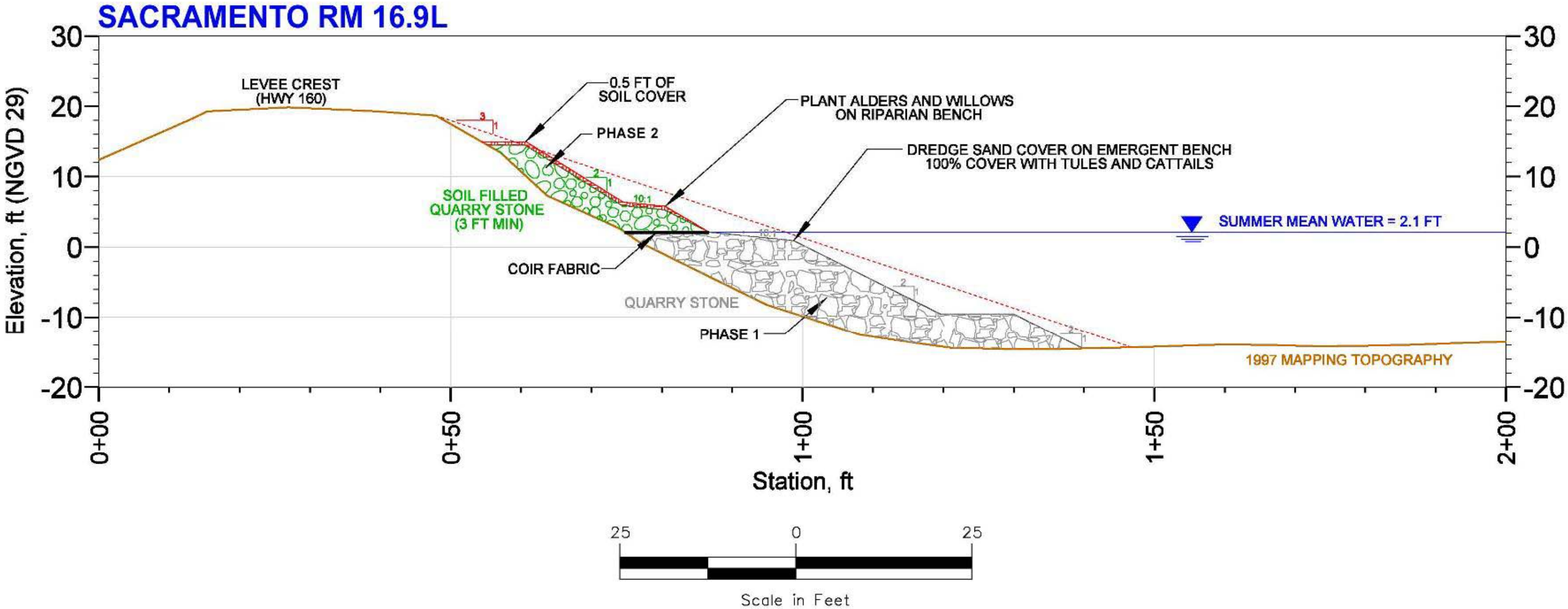

Figure 2. Conceptual cross section Sacramento River Mile 16.9L. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 16.9L CONSTRUCTION EASEMENT COORDINATE TABULATION

POINT	NORTHING	EASTING
P1	1821716.63	6671686.23
P2	1821656.11	6672094.09
P3	1821280.01	6672041.07
P4	1821337.88	6671634.74

Figure 3. Construction easement and Project footprint at Sacramento River Mile 16.9L. Ayres Associates, Sacramento, CA, 22 November 2006.

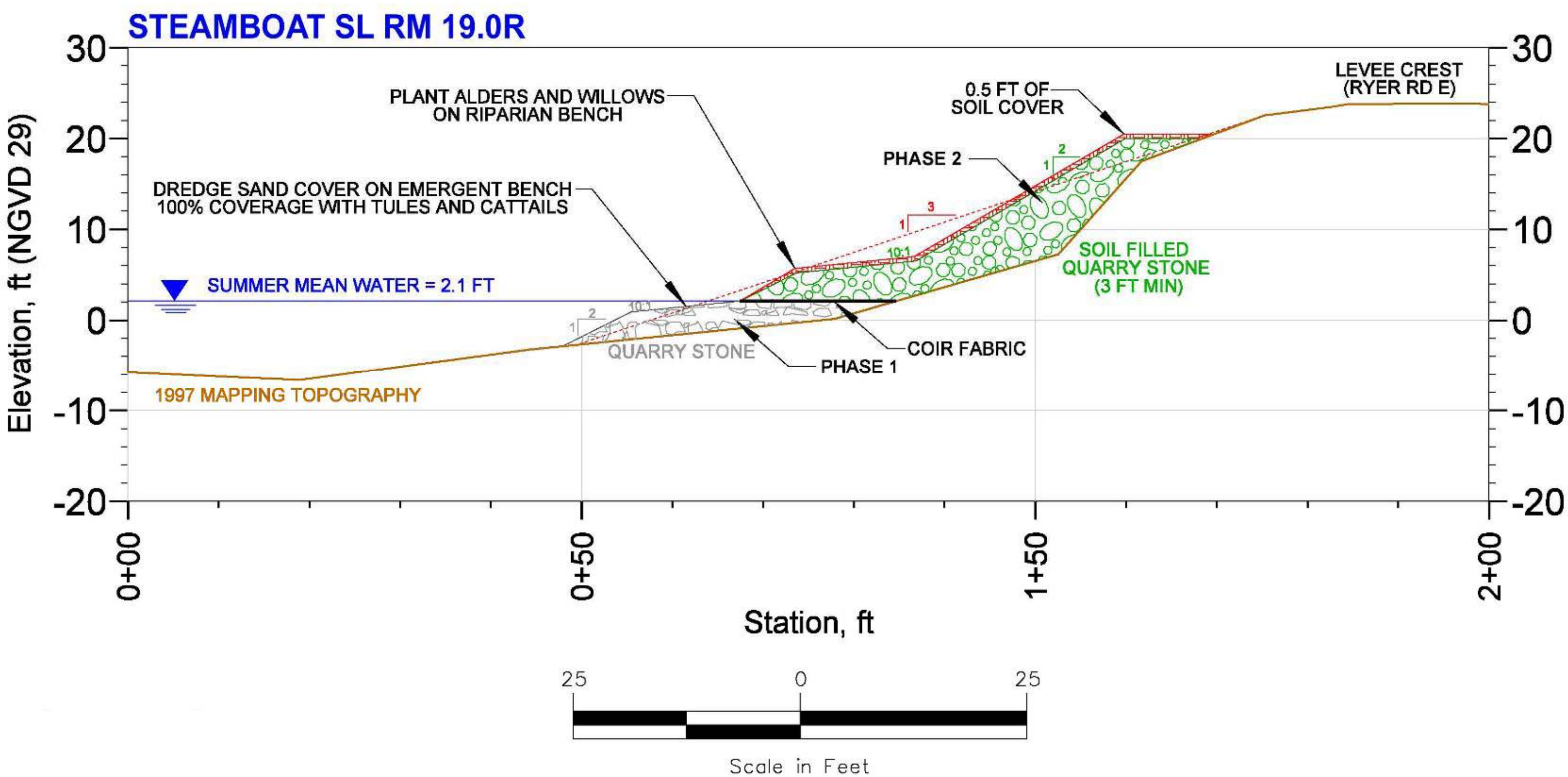

Figure 4. Conceptual cross section Steamboat Slough River Mile 19.0R. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 19.0 R CONSTRUCTION EASEMENT COORDINATE TABULATION

POINT	NORTHING	EASTING
P1	1841087.12	6674827.65
P2	1840906.63	6675044.94
P3	1840334.40	6674561.29
P4	1840509.42	6674341.63
P5	1840807.17	6674564.01

Figure 5. Construction easement and Project footprint at Steamboat Slough River Mile 19.0R. Ayres Associates, Sacramento, CA, 22 November 2006.

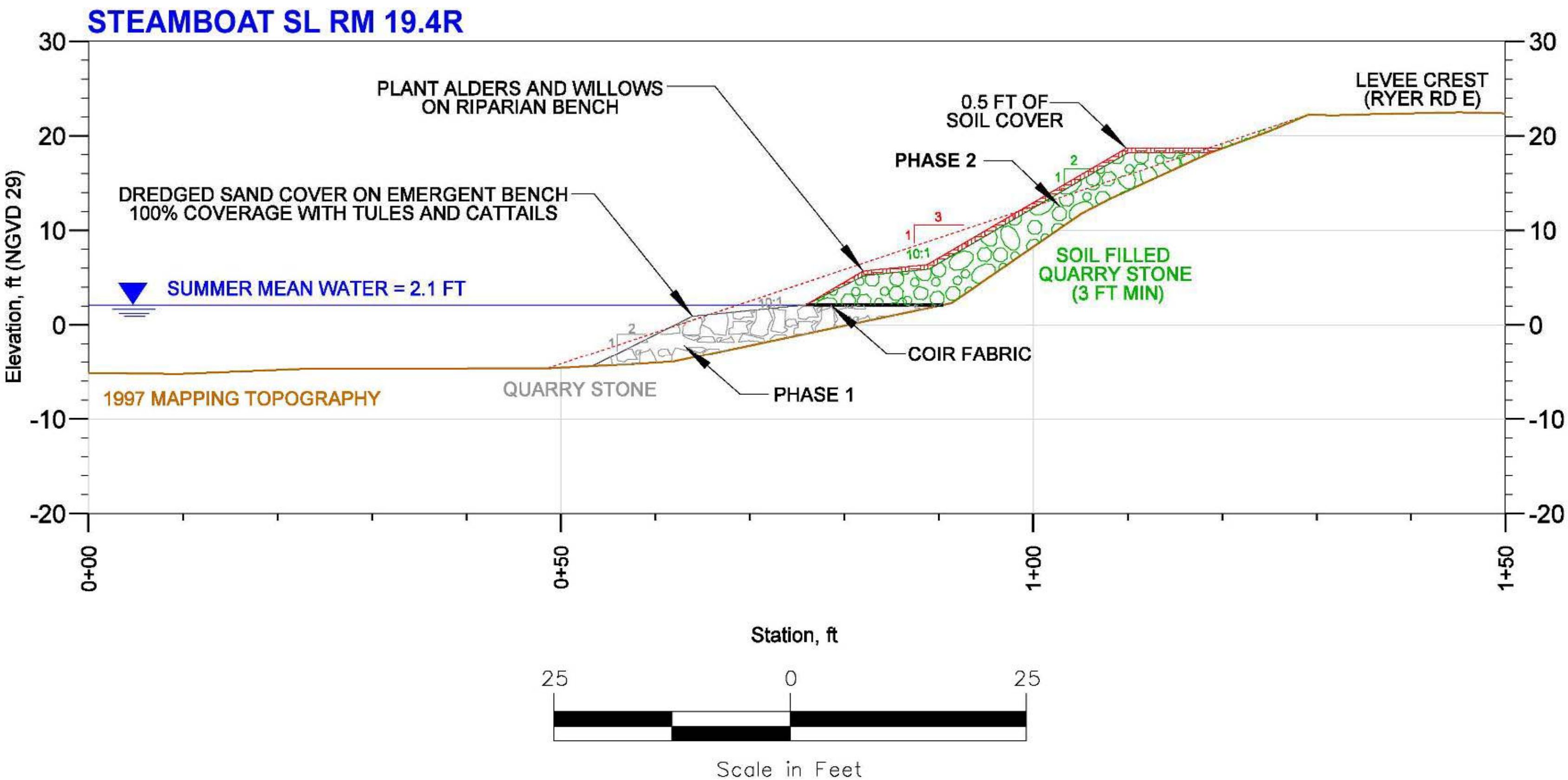

Figure 6. Conceptual cross section Steamboat Slough River Mile 19.4R. Ayres Associates, Sacramento, CA, 8 November 2006.

POINT	NORTHING	EASTING
P1	1842475.48	6675664.93
P2	1842360.74	6675815.65
P3	1841926.01	6675628.53
P4	1842043.99	6675368.89

Figure 7. Construction easement and Project footprint at Steamboat Slough River Mile 19.4R. Ayres Associates, Sacramento, CA, 22 November 2006.

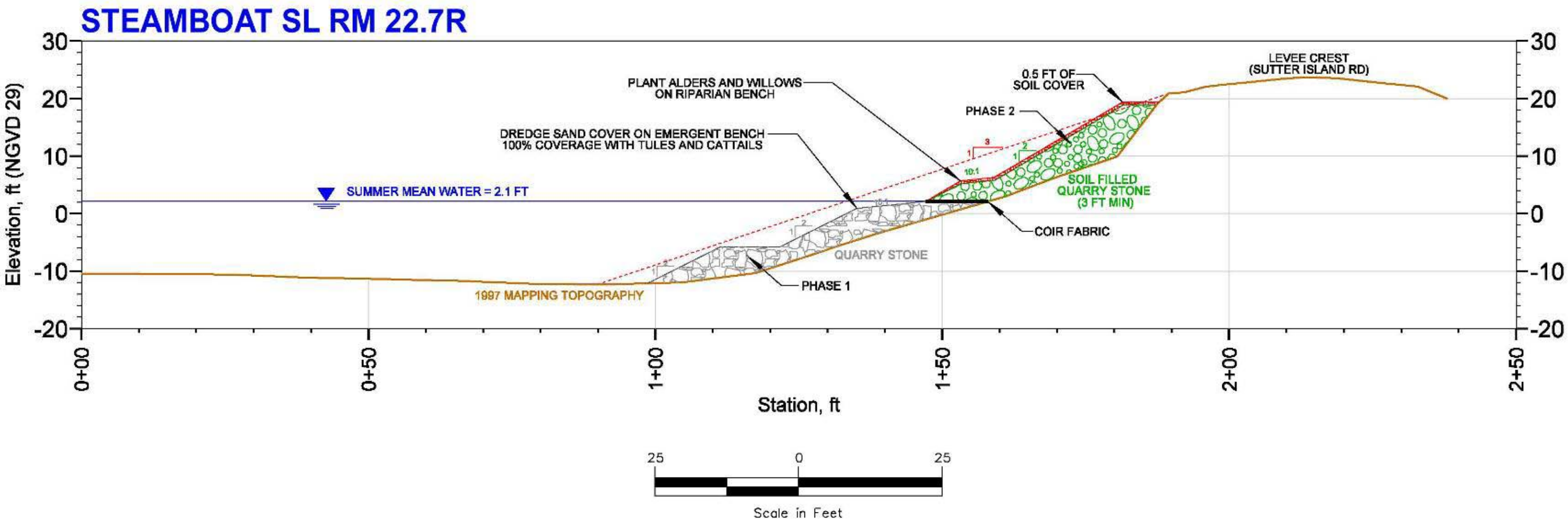

Figure 8. Conceptual cross section Steamboat Slough River Mile 22.7R. Ayres Associates, Sacramento, CA, 8 November 2006.

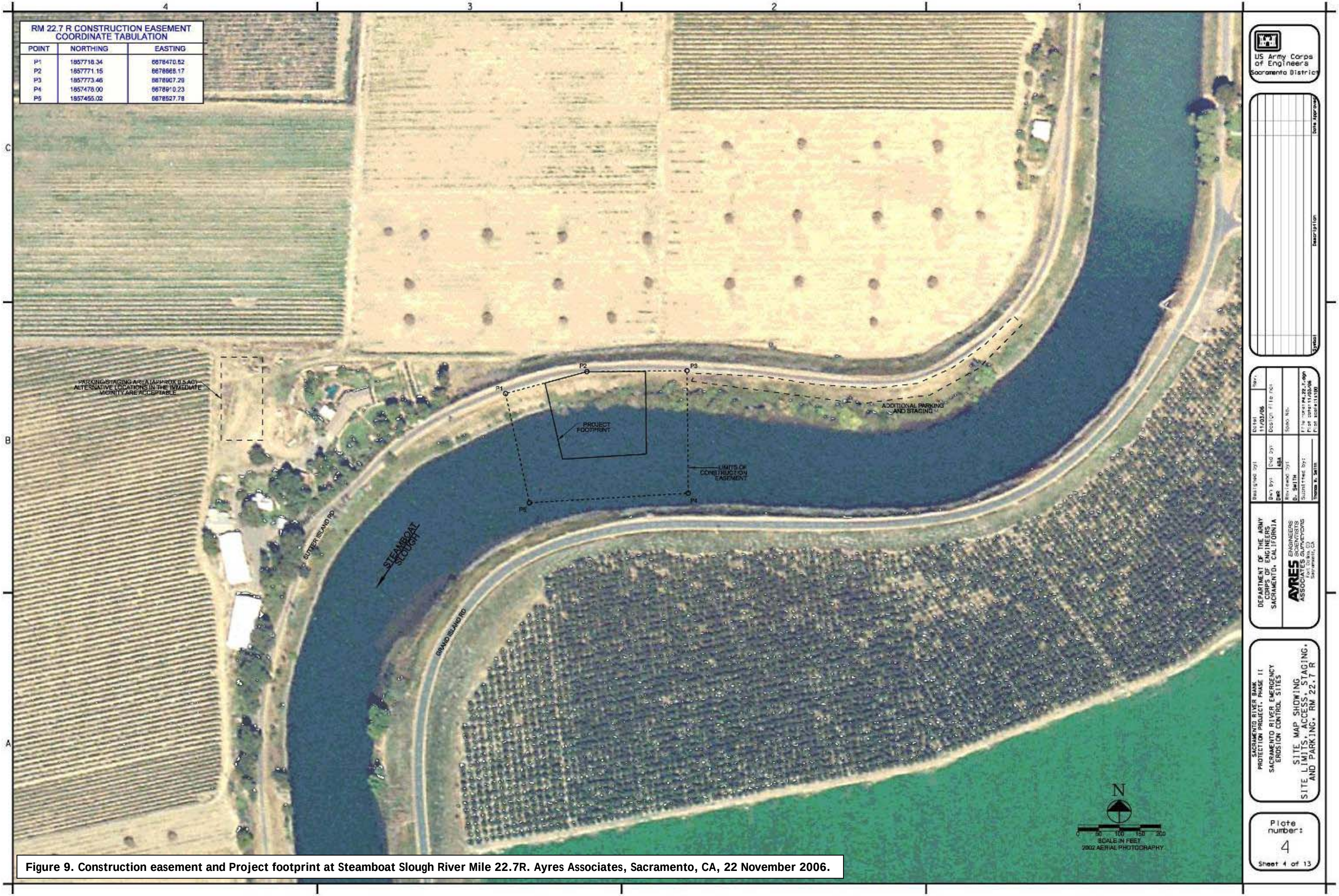

Figure 9. Construction easement and Project footprint at Steamboat Slough River Mile 22.7R. Ayres Associates, Sacramento, CA, 22 November 2006.

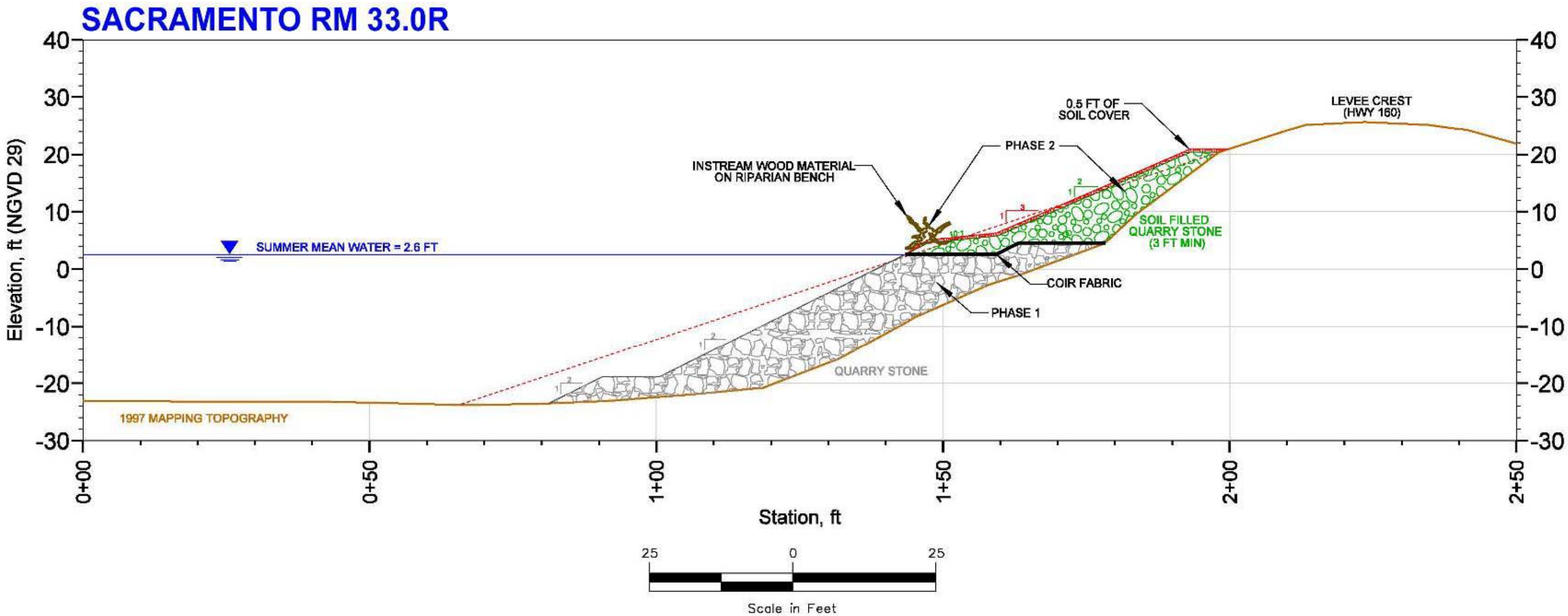

Figure 10. Conceptual cross section Sacramento River Mile 33.0R. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 33.0R CONSTRUCTION EASEMENT COORDINATE TABULATION

POINT	NORTHING	EASTING
P1	1876508.00	6682461.20
P2	1876548.90	6682723.32
P3	1876026.34	6682815.60
P4	1875985.45	6682583.30

Figure 11. Construction easement and Project footprint at Sacramento River Mile 33.0R. Ayres Associates, Sacramento, CA, 22 November 2006.

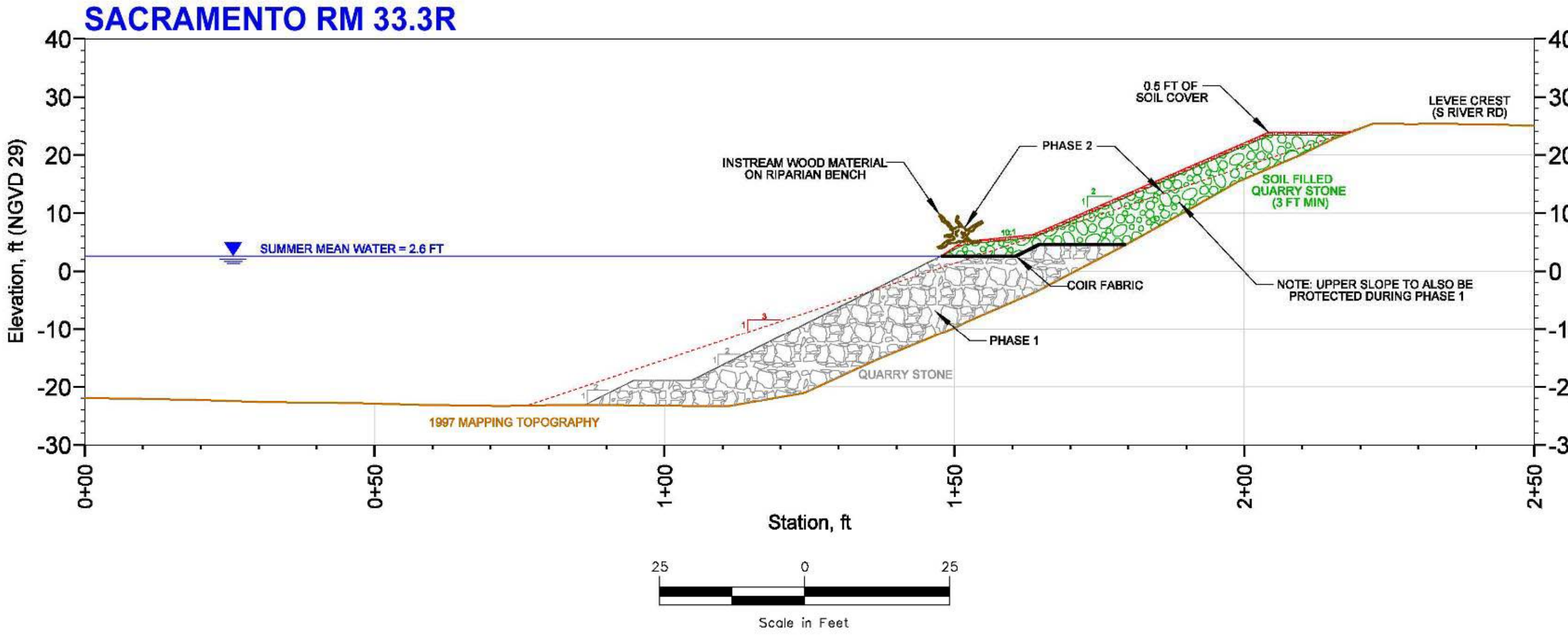

Figure 12. Conceptual cross section Sacramento River Mile 33.3R. Ayres Associates, Sacramento, CA, 8 November 2006.

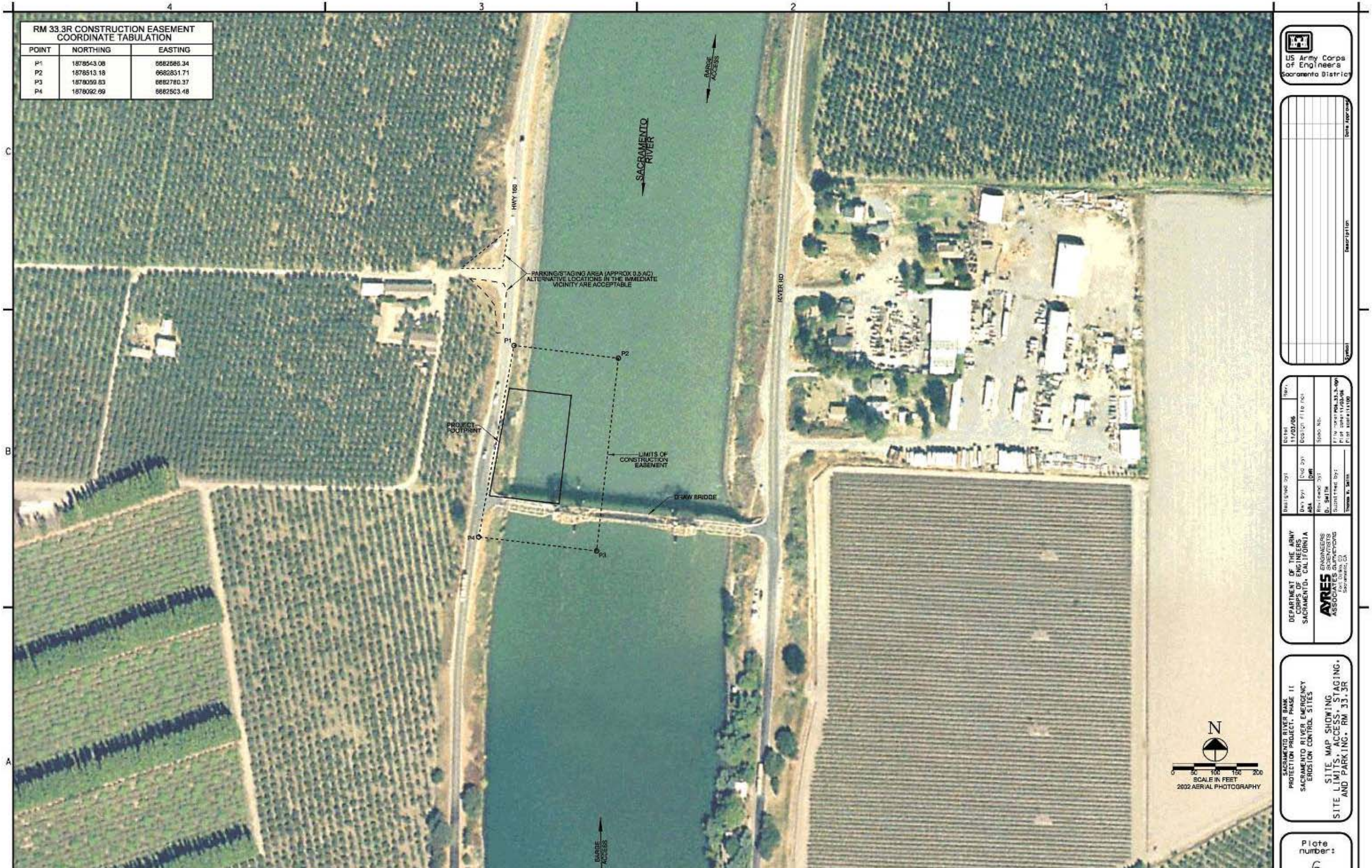

Figure 13. Construction easement and Project footprint at Sacramento River Mile 33.3R. Ayres Associates, Sacramento, CA, 22 November 2006.

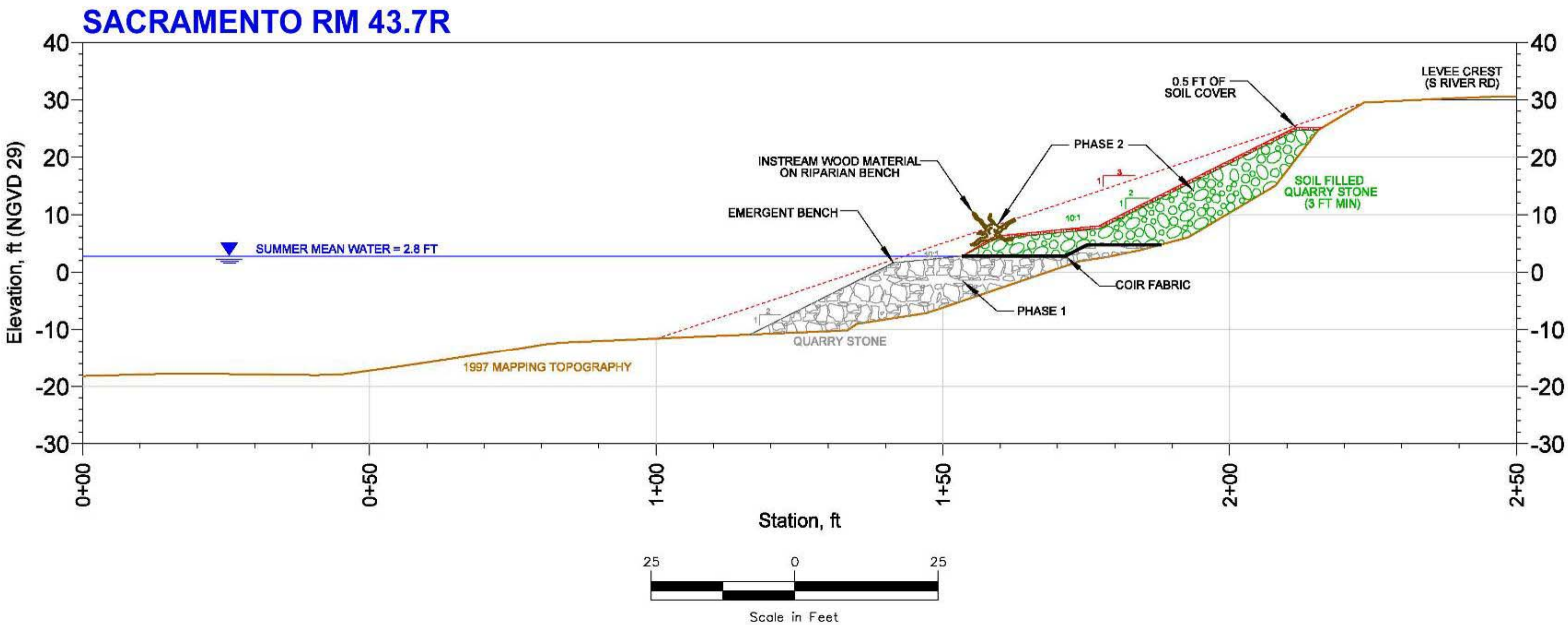

Figure 14. Conceptual cross section Sacramento River Mile 43.7R. Ayres Associates, Sacramento, CA, 8 November 2006.

POINT	NORTHING	EASTING
P1	1920962.74	6697075.07
P2	1920974.09	6697731.36
P3	1920892.75	6698368.20
P4	1920810.09	6698345.38
P5	1920675.78	6697095.52

Figure 15. Construction easement and Project footprint at Sacramento River Mile 43.7R. Ayres Associates, Sacramento, CA, 22 November 2006.

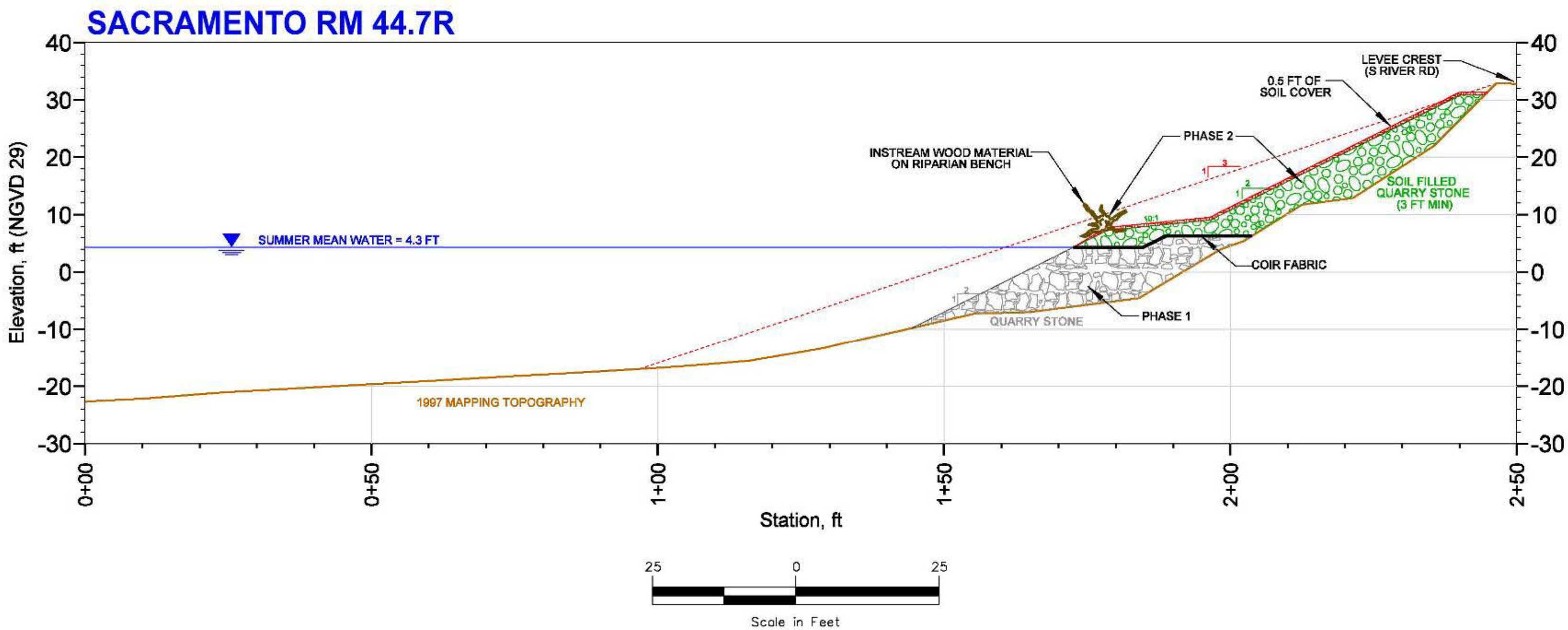

Figure 16. Conceptual cross section Sacramento River Mile 44.7R. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 44.7R CONSTRUCTION EASEMENT COORDINATE TABULATION		
POINT	NORTHING	EASTING
P1	1921128.42	6701449.87
P2	1921407.60	6702105.95
P3	1921625.50	6702495.94
P4	1921972.49	6702933.40
P5	1921767.78	6703187.50
P6	1921349.52	6702629.09
P7	1921122.02	6702216.94
P8	1920829.14	6701598.34

Figure 17. Construction easement and Project footprint at Sacramento River Mile 44.7R. Ayres Associates, Sacramento, CA, 22 November 2006.

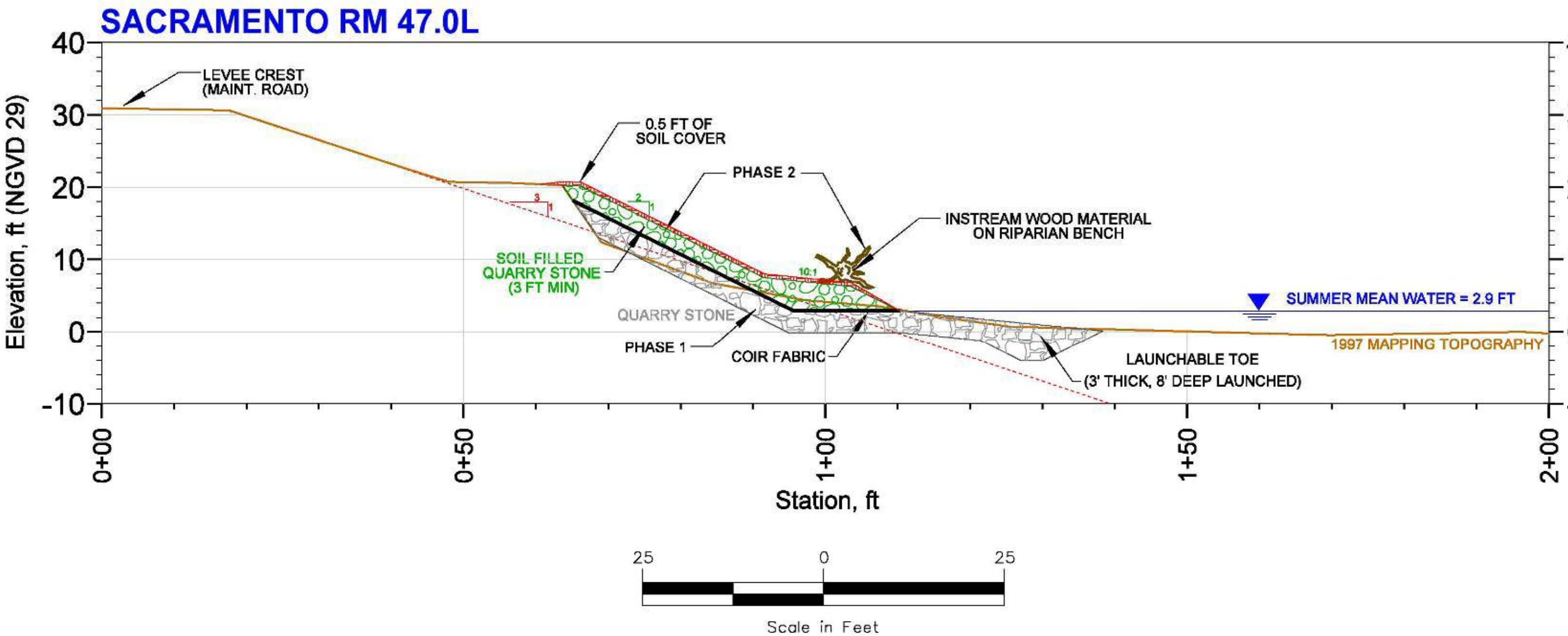

Figure 18. Conceptual cross section Sacramento River Mile 47.0L. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 47.0L CONSTRUCTION EASEMENT COORDINATE TABULATION

POINT	NORTHING	EASTING
P1	1934106.51	6703382.20
P2	1933613.76	6703712.42
P3	1933233.71	6703806.27
P4	1932736.64	6703834.08
P5	1932721.25	6703499.70
P6	1933154.41	6703464.15
P7	1933459.03	6703380.54
P8	1933913.03	6703089.83

Figure 19. Construction easement and Project footprint at Sacramento River Mile 47.0L. Ayres Associates, Sacramento, CA, 22 November 2006.

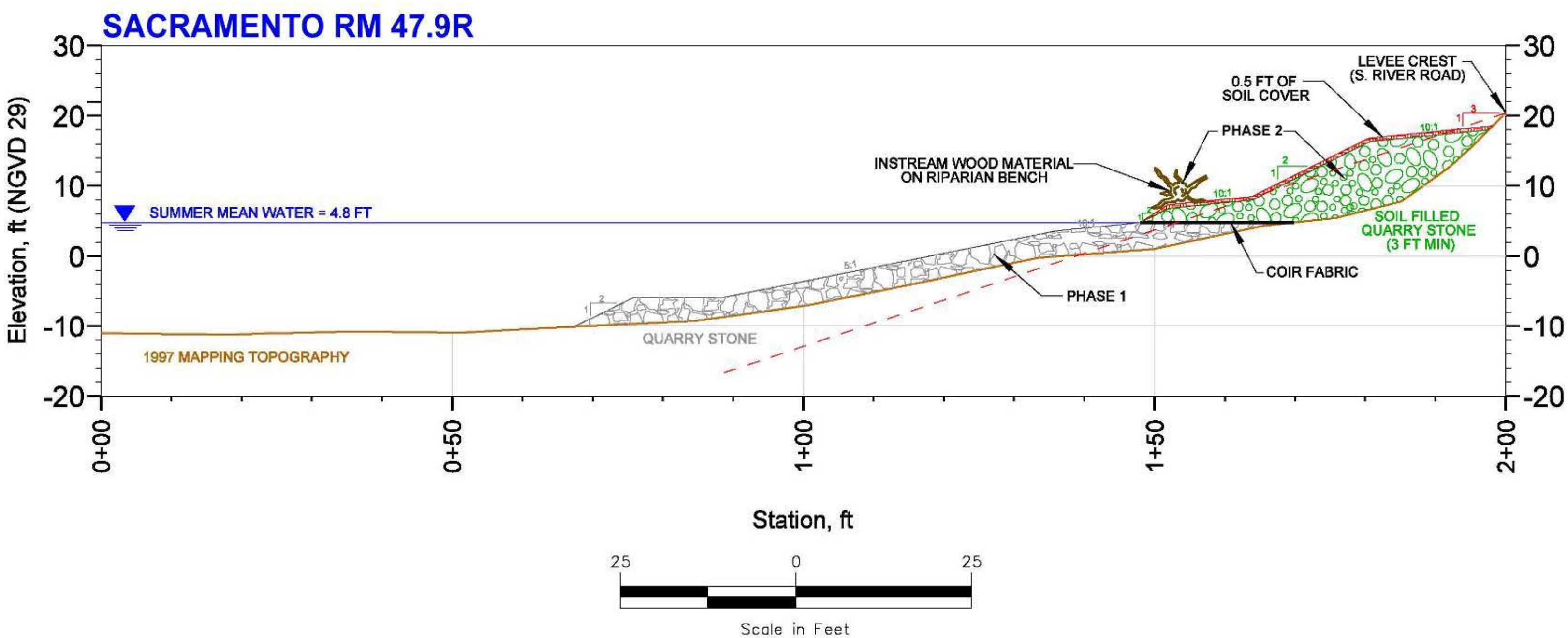

Figure 20. Conceptual cross section Sacramento River Mile 47.9R. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 47.9R & 48.2R CONSTRUCTION EASEMENT COORDINATE TABULATION

POINT	NORTHING	EASTING
P1	1934787.84	6697723.22
P2	1934884.86	6699029.12
P3	1934798.73	6700195.08
P4	1934469.73	6700162.81
P5	1934529.11	6699636.64
P6	1934572.00	6698955.42
P7	1934814.27	6699299.06
P8	1934494.48	6697759.58

US Army Corps of Engineers Sacramento District

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

AYRES ASSOCIATES ENGINEERS SCIENTISTS SURVEYORS Fort Collins, CO Sacramento, CA

Designed by: | Dwn by: ABA | Ckd by: DWR | Reviewed by: D. SMITH | Submitted by: Thomas W. Smith | Date: 11/03/06 | Design file no: | Scale No.:

SACRAMENTO RIVER BANK PROTECTION PROJECT, PHASE II

SACRAMENTO RIVER EMERGENCY EROSION CONTROL SITES

SITE MAP SHOWING SITE LIMITS, ACCESS, STAGING, AND PARKING, RM 47.9R & 48.2R

Plate number: 10

Sheet 10 of 13

Figure 21. Construction easement and Project footprint at Sacramento River Mile 48.0R. This figure is a combination of sites 47.9R (east of P6) and 48.2R (west of P6) Into one large site 48.0R. Ayres Associates, Sacramento, CA, 22 November 2006.

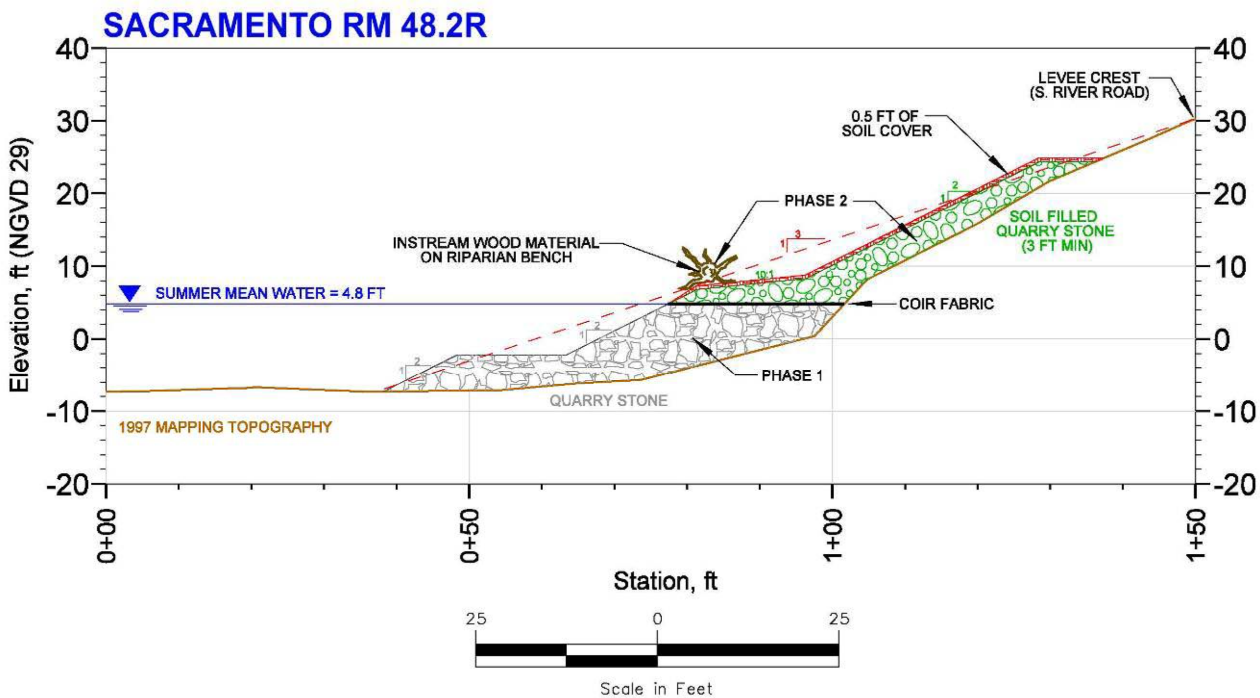

Figure 22. Conceptual cross section Sacramento River Mile 48.2R. Ayres Associates, Sacramento, CA, 8 November 2006.

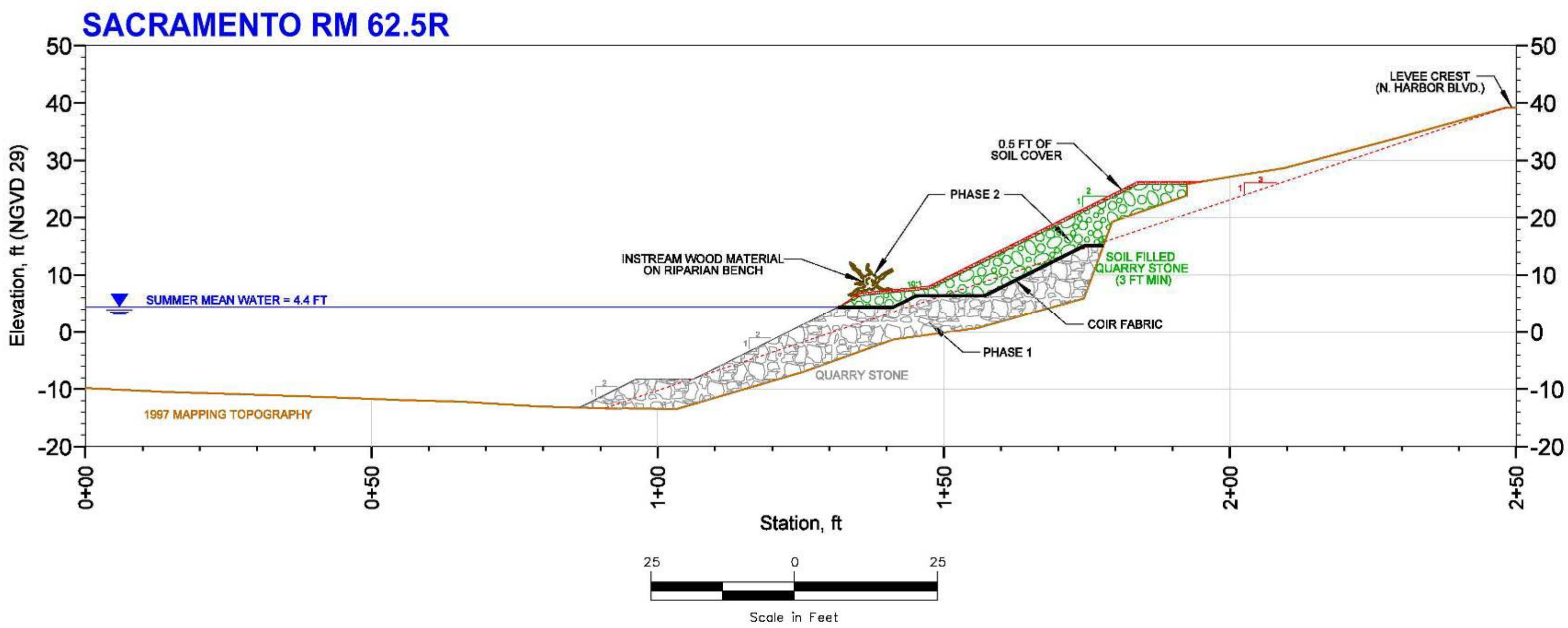

Figure 23. Conceptual cross section Sacramento River Mile 62.5R. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 62.5R CONSTRUCTION EASEMENT COORDINATE TABULATION		
POINT	NORTHING	EASTING
P1	1978847.22	6890818.06
P2	1978791.41	6891152.03
P3	1978494.32	6891070.67
P4	1978554.05	6890846.24
P5	1978647.98	6890653.58

Figure 24. Construction easement and Project footprint at Sacramento River Mile 62.5R. Ayres Associates, Sacramento, CA, 22 November 2006.

US Army Corps of Engineers
Sacramento District

Symbol | Description | Date | Approved

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

AYRES ASSOCIATES ENGINEERS SCIENTISTS SURVEYORS
Fort Collins, CO
Sacramento, CA

Designed by: | Date: 11/03/06 | Rev.
Dwn by: ABA | Ckd by: DMR | Design file no:
Reviewed by: D. SMITH | Spec No.
Submitted by: Thomas A. Smith | File name: P11_62_5.dgn Plot date: 11/03/06 Plot scale: 1:100

SACRAMENTO RIVER BANK PROTECTION PROJECT, PHASE II
SACRAMENTO RIVER EMERGENCY EROSION CONTROL SITES

SITE MAP SHOWING
SITE LIMITS, ACCESS, STAGING,
AND PARKING, RM 62.5R

Plate number:
11
Sheet 11 of 13

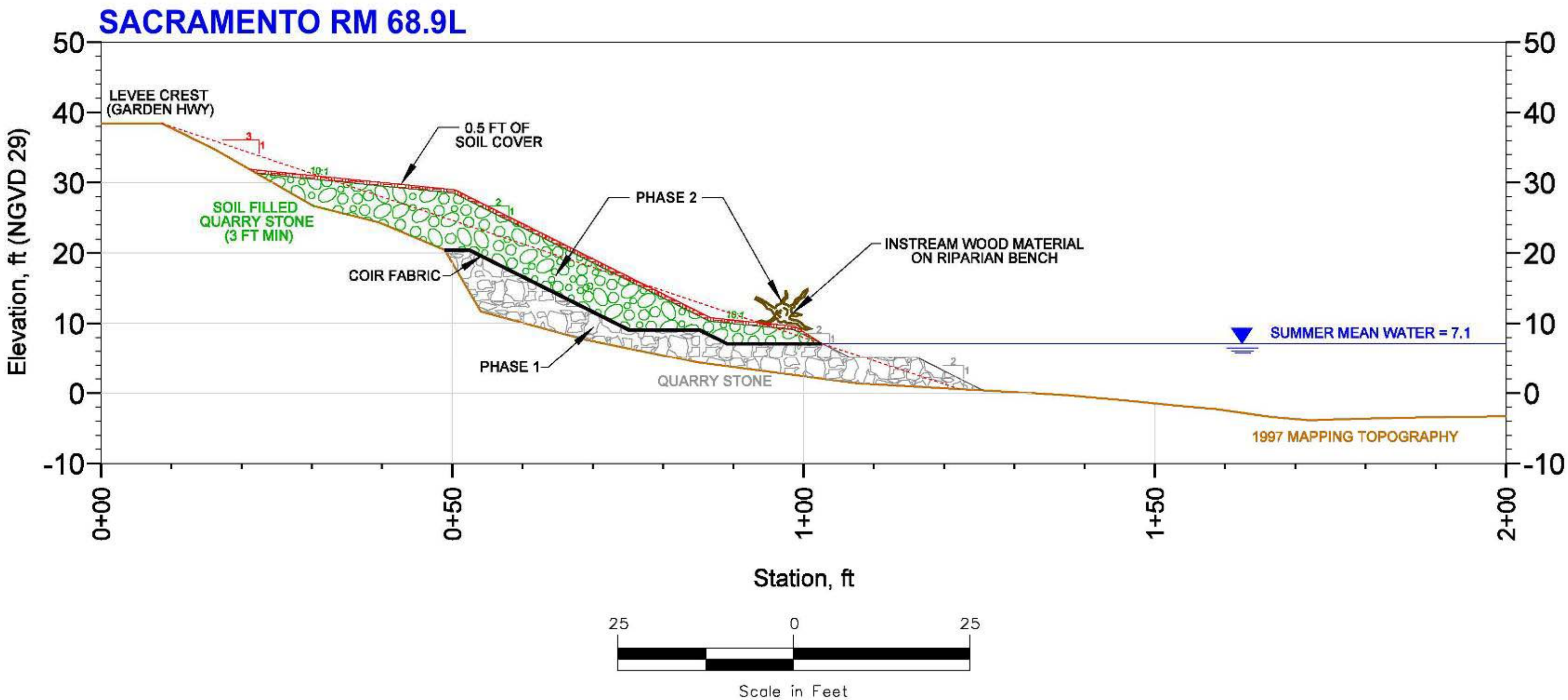

Figure 25. Conceptual cross section Sacramento River Mile 68.9L. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 68.9 L CONSTRUCTION EASEMENT COORDINATE TABULATION

POINT	NORTHING	EASTING
P1	2001541.23	6674389.80
P2	2001696.99	6674846.79
P3	2000880.82	6675209.85
P4	2000701.07	6674935.45

Figure 26. Construction easement and Project footprint at Sacramento River Mile 68.9L. Ayres Associates, Sacramento, CA, 22 November 2006.

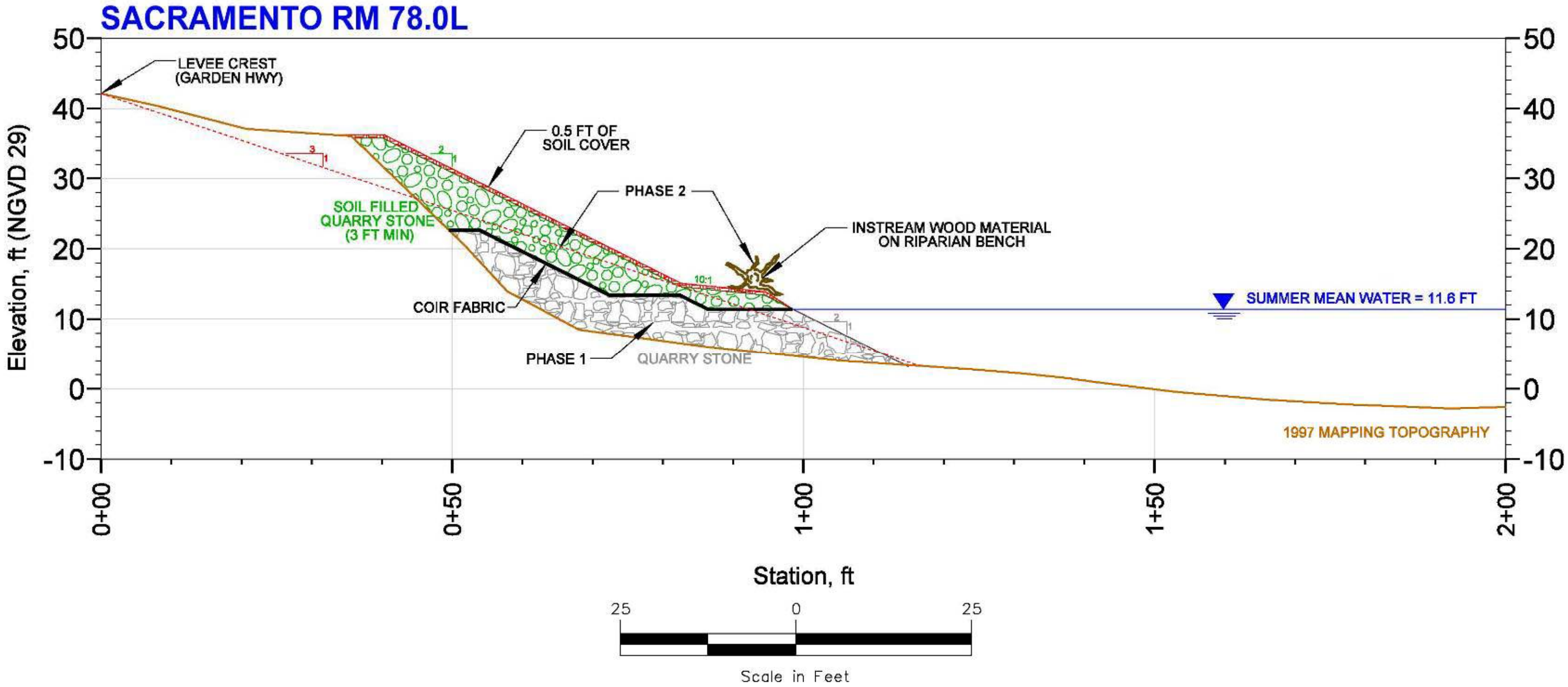

Figure 27. Conceptual cross section Sacramento River Mile 78.0L. Ayres Associates, Sacramento, CA, 8 November 2006.

RM 78.0 L CONSTRUCTION EASEMENT COORDINATE TABULATION		
POINT	NORTHING	EASTING
P1	2042810.03	6676487.50
P2	2042932.98	6676828.29
P3	2041812.46	6677410.08
P4	2041074.52	6677030.43

Figure 28. Construction easement and Project footprint at Sacramento River Mile 78.0L. Ayres Associates, Sacramento, CA, 22 November 2006.

Appendix B

Standardized Assessment Methodology
(SAM)
Modeling Results

From:
Corps 2006, Environmental Assessment for Levee Repair of 14 Winter 2006 Critical Sites, Sacramento River Bank Protection Project
Appendix I, SAM Data and Results

Table I-32
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 16.9

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-58		-3	17		-16		0	-14		-25		-6	-14		-59		1	38	
Year 5	-58		7	70		6		16	58		0		19	67		-59		8	77	
Year 15	-51		15	88		13		27	86		11		35	94		-52		16	93	
Year 25	-45		21	96		17		35	100		17		43	102		-46		22	101	
Year 50	-39		25	103		22		42	112		22		49	107		-40		26	107	
Central Valley fall-run chinook salmon																				
Year 0	0		0	0				0	0		0			0		0			0	
Year 1	-58		-3	17				0	-14		-25			-14		-59			38	
Year 5	-58		7	70				16	58		0			67		-59			77	
Year 15	-51		15	88				27	86		11			94		-52			93	
Year 25	-45		21	96				35	100		17			102		-46			101	
Year 50	-39		25	103				42	112		22			107		-40			107	
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0	0					0	
Year 1	-58			17		-16			-14		-25		-6	-14					38	
Year 5	-58			70		6			58		0		19	67					77	
Year 15	-51			88		13			86		11		35	94					93	
Year 25	-45			96		17			100		17		43	102					101	
Year 50	-39			103		22			112		22		49	107					107	
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-58		-3	17		-16		0	-14		-25		-6	-14		-59		1		
Year 5	-58		7	70		6		16	58		0		19	67		-59		8		
Year 15	-51		15	88		13		27	86		11		35	94		-52		16		
Year 25	-45		21	96		17		35	100		17		43	102		-46		22		
Year 50	-39		25	103		22		42	112		22		49	107		-40		26		
Central Valley steelhead																				
Year 0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0
Year 1	-105		-4	-1	-105	-30		1	-21	-41	-41		-7	-28	-41	-107		3	18	-107
Year 5	-105		12	42	-105	14		26	35	8	8		28	36	8	-107		14	48	-107
Year 15	-95		24	58	-95	30		41	56	28	28		49	57	28	-98		25	62	-98
Year 25	-87		32	66	-87	37		50	66	36	36		59	64	36	-90		33	70	-90
Year 50	-81		38	73	-81	45		60	76	43	43		67	69	43	-83		40	76	-83
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-92	-92		0	0	-98	-98		0	0	-28	-28		0
Year 5	0				0	0	-2	-2		0	0	-6	-6		0	0	17	17		0
Year 15	0				0	0	14	14		0	0	10	10		0	0	24	24		0
Year 25	0				0	0	17	17		0	0	13	13		0	0	26	26		0
Year 50	0				0	0	19	19		0	0	15	15		0	0	27	27		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-33
SAM results showing bank-line weighted relative response (feet) at Steamboat Slough RM 19

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-75		-23	-32		-28		-28	-110		-39		-49	-115		-76		-22	-26	
Year 5	-75		-16	12		1		-4	-11		-7		-14	-6		-76		-14	19	
Year 15	-66		-6	33		12		11	28		8		9	31		-68		-5	39	
Year 25	-58		1	44		17		22	47		16		20	41		-60		2	48	
Year 50	-51		7	52		23		33	63		23		29	49		-54		7	55	
Central Valley fall-run chinook salmon																				
Year 0	0		0	0				0	0		0			0		0			0	
Year 1	-75		-23	-32				-28	-110		-39			-115		-76			-26	
Year 5	-75		-16	12				-4	-11		-7			-6		-76			19	
Year 15	-66		-6	33				11	28		8			31		-68			39	
Year 25	-58		1	44				22	47		16			41		-60			48	
Year 50	-51		7	52				33	63		23			49		-54			55	
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0	0					0	
Year 1	-75			-32		-28			-110		-39		-49	-115					-26	
Year 5	-75			12		1			-11		-7		-14	-6					19	
Year 15	-66			33		12			28		8		9	31					39	
Year 25	-58			44		17			47		16		20	41					48	
Year 50	-51			52		23			63		23		29	49					55	
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-75		-23	-32		-28		-28	-110		-39		-49	-115		-76		-22		
Year 5	-75		-16	12		1		-4	-11		-7		-14	-6		-76		-14		
Year 15	-66		-6	33		12		11	28		8		9	31		-68		-5		
Year 25	-58		1	44		17		22	47		16		20	41		-60		2		
Year 50	-51		7	52		23		33	63		23		29	49		-54		7		
Central Valley steelhead																				
Year 0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0
Year 1	-141		-37	-44	-141	-54		-42	-94	-69	-69		-67	-105	-69	-141		-35	-38	-141
Year 5	-141		-24	-9	-141	5		-6	-16	-4	-4		-17	-19	-4	-141		-22	-3	-141
Year 15	-129		-10	9	-129	26		15	12	22	22		12	9	22	-130		-8	14	-130
Year 25	-118		0	20	-118	36		28	26	33	33		25	19	33	-120		1	23	-120
Year 50	-110		8	28	-110	47		42	39	42	42		36	26	42	-112		9	31	-112
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-131	-131		0	0	-135	-135		0	0	-42	-42		0
Year 5	0				0	0	-6	-6		0	0	-10	-10		0	0	12	12		0
Year 15	0				0	0	15	15		0	0	11	11		0	0	21	21		0
Year 25	0				0	0	19	19		0	0	15	15		0	0	22	22		0
Year 50	0				0	0	22	22		0	0	18	18		0	0	24	24		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-34
SAM results showing bank-line weighted relative response (feet) at Steamboat Slough RM 19.4

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-19		1	17		1		-3	-20		-3		-4	-12		-19		2	19	
Year 5	-19		5	38		14		7	26		11		11	36		-19		6	40	
Year 15	-16		8	45		19		14	43		17		20	50		-16		9	47	
Year 25	-13		11	48		22		19	50		20		24	54		-13		12	50	
Year 50	-10		13	51		24		23	57		23		27	56		-11		13	52	
Central Valley fall-run chinook salmon																				
Year 0	0		0	0				0	0		0			0		0			0	
Year 1	-19		1	17				-3	-20		-3			-12		-19			19	
Year 5	-19		5	38				7	26		11			36		-19			40	
Year 15	-16		8	45				14	43		17			50		-16			47	
Year 25	-13		11	48				19	50		20			54		-13			50	
Year 50	-10		13	51				23	57		23			56		-11			52	
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0	0					0	
Year 1	-19			17		1			-20		-3		-4	-12					19	
Year 5	-19			38		14			26		11		11	36					40	
Year 15	-16			45		19			43		17		20	50					47	
Year 25	-13			48		22			50		20		24	54					50	
Year 50	-10			51		24			57		23		27	56					52	
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-19		1	17		1		-3	-20		-3		-4	-12		-19		2		
Year 5	-19		5	38		14		7	26		11		11	36		-19		6		
Year 15	-16		8	45		19		14	43		17		20	50		-16		9		
Year 25	-13		11	48		22		19	50		20		24	54		-13		12		
Year 50	-10		13	51		24		23	57		23		27	56		-11		13		
Central Valley steelhead																				
Year 0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0
Year 1	-29		0	11	-29	5		-6	-19	3	3		-7	-15	3	-28		2	14	-28
Year 5	-29		7	27	-29	33		11	17	32	32		14	22	32	-28		9	30	-28
Year 15	-25		12	33	-25	42		20	29	42	42		25	33	42	-24		13	36	-24
Year 25	-21		15	37	-21	47		25	35	47	47		30	36	47	-21		16	39	-21
Year 50	-18		18	39	-18	52		31	41	50	50		34	39	50	-18		19	41	-18
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-12	-12		0	0	-13	-13		0	0	19	19		0
Year 5	0				0	0	45	45		0	0	42	42		0	0	43	43		0
Year 15	0				0	0	54	54		0	0	51	51		0	0	47	47		0
Year 25	0				0	0	56	56		0	0	53	53		0	0	48	48		0
Year 50	0				0	0	57	57		0	0	55	55		0	0	48	48		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-35
SAM results showing bank-line weighted relative response (feet) at Steamboat Slough RM 22.7

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-24		-2	4		-9		-6	-27		-12		-8	-22		-24		-1	5	
Year 5	-24		1	19		0		2	5		-2		3	12		-24		2	20	
Year 15	-21		4	24		4		7	17		2		9	22		-21		4	25	
Year 25	-19		5	25		5		10	22		4		12	24		-19		6	27	
Year 50	-18		6	27		7		13	27		6		14	26		-18		7	28	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-24		-2					-6	-27		-12			-22		-24				
Year 5	-24		1					2	5		-2			12		-24				
Year 15	-21		4					7	17		2			22		-21				
Year 25	-19		5					10	22		4			24		-19				
Year 50	-18		6					13	27		6			26		-18				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-24			4		-9			-27		-12		-8							
Year 5	-24			19		0			5		-2		3							
Year 15	-21			24		4			17		2		9							
Year 25	-19			25		5			22		4		12							
Year 50	-18			27		7			27		6		14							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-24		-2	4		-9		-6	-27		-12		-8	-22		-24		-1		
Year 5	-24		1	19		0		2	5		-2		3	12		-24		2		
Year 15	-21		4	24		4		7	17		2		9	22		-21		4		
Year 25	-19		5	25		5		10	22		4		12	24		-19		6		
Year 50	-18		6	27		7		13	27		6		14	26		-18		7		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-42		-4		-42	-17		-10	-24	-19	-19		-12	-22	-19	-42		-3		-42
Year 5	-42		1		-42	2		2	1	1	1		4	5	1	-42		2		-42
Year 15	-39		4		-39	9		9	10	9	9		11	13	9	-39		5		-39
Year 25	-37		6		-37	12		13	14	12	12		15	15	12	-37		8		-37
Year 50	-35		8		-35	15		17	18	14	14		17	17	14	-35		9		-35
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-29	-29		0	0	-30	-30		0	0	-1	-1		0
Year 5	0				0	0	11	11		0	0	10	10		0	0	16	16		0
Year 15	0				0	0	18	18		0	0	16	16		0	0	19	19		0
Year 25	0				0	0	19	19		0	0	17	17		0	0	20	20		0
Year 50	0				0	0	20	20		0	0	18	18		0	0	20	20		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-36
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 33

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-23		-4	-15		-1		10	25		-5		8	19		-23		-3	-5	
Year 5	-23		-3	-7		14		22	74		11		26	75		-23		-3	-5	
Year 15	-18		-1	-2		19		30	94		19		40	98		-18		-1	-1	
Year 25	-14		0	2		22		36	104		23		47	104		-14		0	3	
Year 50	-10		1	5		25		42	113		27		53	110		-10		1	5	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-23		-4					10	25		-5			19		-23				
Year 5	-23		-3					22	74		11			75		-23				
Year 15	-18		-1					30	94		19			98		-18				
Year 25	-14		0					36	104		23			104		-14				
Year 50	-10		1					42	113		27			110		-10				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-23			-15		-1			25		-5		8							
Year 5	-23			-7		14			74		11		26							
Year 15	-18			-2		19			94		19		40							
Year 25	-14			2		22			104		23		47							
Year 50	-10			5		25			113		27		53							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-23		-4	-15		-1		10	25		-5		8	19		-23		-3		
Year 5	-23		-3	-7		14		22	74		11		26	75		-23		-3		
Year 15	-18		-1	-2		19		30	94		19		40	98		-18		-1		
Year 25	-14		0	2		22		36	104		23		47	104		-14		0		
Year 50	-10		1	5		25		42	113		27		53	110		-10		1		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-42		-7		-42	2		15	19	-5	-5		13	13	-5	-42		-4		-42
Year 5	-42		-5		-42	31		34	58	27	27		38	56	27	-42		-4		-42
Year 15	-35		-1		-35	41		45	73	41	41		55	74	41	-35		-1		-35
Year 25	-29		1		-29	46		52	80	48	48		64	80	48	-29		1		-29
Year 50	-24		3		-24	52		60	88	53	53		71	85	53	-24		3		-24
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-11	-11		0	0	-12	-12		0	0	-39	-39		0
Year 5	0				0	0	52	52		0	0	51	51		0	0	-39	-39		0
Year 15	0				0	0	63	63		0	0	62	62		0	0	-39	-39		0
Year 25	0				0	0	65	65		0	0	64	64		0	0	-39	-39		0
Year 50	0				0	0	67	67		0	0	66	66		0	0	-39	-39		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-37
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 33.3

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-16		-2	-4		0		7	19		-4		8	22		-16		-1	3	
Year 5	-16		-1	2		9		16	53		7		21	59		-16		-1	3	
Year 15	-14		0	5		13		22	67		12		29	72		-14		0	5	
Year 25	-11		1	6		15		26	73		14		33	76		-11		1	7	
Year 50	-9		1	8		16		30	78		17		37	78		-9		1	8	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-16		-2					7	19		-4			22		-16				
Year 5	-16		-1					16	53		7			59		-16				
Year 15	-14		0					22	67		12			72		-14				
Year 25	-11		1					26	73		14			76		-11				
Year 50	-9		1					30	78		17			78		-9				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-16			-4		0			19		-4		8							
Year 5	-16			2		9			53		7		21							
Year 15	-14			5		13			67		12		29							
Year 25	-11			6		15			73		14		33							
Year 50	-9			8		16			78		17		37							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-16		-2	-4		0		7	19		-4		8	22		-16		-1		
Year 5	-16		-1	2		9		16	53		7		21	59		-16		-1		
Year 15	-14		0	5		13		22	67		12		29	72		-14		0		
Year 25	-11		1	6		15		26	73		14		33	76		-11		1		
Year 50	-9		1	8		16		30	78		17		37	78		-9		1		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-27		-3		-27	1		11	15	-3	-3		12	15	-3	-27		-1		-27
Year 5	-27		-1		-27	21		24	42	19	19		29	44	19	-27		-1		-27
Year 15	-23		1		-23	28		32	52	27	27		40	54	27	-23		1		-23
Year 25	-20		2		-20	31		37	57	31	31		45	58	31	-20		2		-20
Year 50	-17		3		-17	35		42	61	34	34		49	60	34	-17		3		-17
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	3	3		0	0	3	3		0	0	-19	-19		0
Year 5	0				0	0	46	46		0	0	46	46		0	0	-19	-19		0
Year 15	0				0	0	53	53		0	0	53	53		0	0	-19	-19		0
Year 25	0				0	0	54	54		0	0	54	54		0	0	-19	-19		0
Year 50	0				0	0	56	56		0	0	55	55		0	0	-19	-19		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-38
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 43.7

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-73		-4	37		-3		-12	-74		-17		-23	-63		-72		-4	39	
Year 5	-73		8	106		42		26	77		32		33	105		-72		9	108	
Year 15	-59		23	137		57		50	137		54		68	159		-59		23	137	
Year 25	-47		33	152		66		66	163		65		84	174		-48		33	151	
Year 50	-37		41	163		74		84	188		76		98	185		-38		41	161	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-73		-4					-12	-74		-17			-63		-72				
Year 5	-73		8					26	77		32			105		-72				
Year 15	-59		23					50	137		54			159		-59				
Year 25	-47		33					66	163		65			174		-48				
Year 50	-37		41					84	188		76			185		-38				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-73			37		-3			-74		-17		-23							
Year 5	-73			106		42			77		32		33							
Year 15	-59			137		57			137		54		68							
Year 25	-47			152		66			163		65		84							
Year 50	-37			163		74			188		76		98							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-73		-4	37		-3		-12	-74		-17		-23	-63		-72		-4		
Year 5	-73		8	106		42		26	77		32		33	105		-72		9		
Year 15	-59		23	137		57		50	137		54		68	159		-59		23		
Year 25	-47		33	152		66		66	163		65		84	174		-48		33		
Year 50	-37		41	163		74		84	188		76		98	185		-38		41		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-119		-9		-119	6		-22	-68	-9	-9		-36	-69	-9	-117		-8		-117
Year 5	-119		11		-119	96		36	51	90	90		41	61	90	-117		12		-117
Year 15	-101		32		-101	127		67	94	128	128		85	104	128	-100		32		-100
Year 25	-86		47		-86	143		88	114	145	145		105	117	145	-86		46		-86
Year 50	-74		58		-74	158		109	133	159	159		121	128	159	-74		57		-74
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-66	-66		0	0	-67	-67		0	0	42	42		0
Year 5	0				0	0	125	125		0	0	126	126		0	0	123	123		0
Year 15	0				0	0	157	157		0	0	158	158		0	0	136	136		0
Year 25	0				0	0	164	164		0	0	164	164		0	0	139	139		0
Year 50	0				0	0	168	168		0	0	169	169		0	0	141	141		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-39
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 44.7

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-199		-64	-187		-75		-35	-181		-101		-44	-133		-199		-64	-187	
Year 5	-199		-64	-187		5		41	101		-15		70	175		-199		-64	-186	
Year 15	-179		-59	-179		32		88	207		23		131	263		-179		-59	-178	
Year 25	-162		-55	-172		47		119	254		41		159	286		-162		-54	-171	
Year 50	-148		-51	-167		62		152	295		58		181	303		-148		-51	-167	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-199		-64					-35	-181		-101			-133		-199				
Year 5	-199		-64					41	101		-15			175		-199				
Year 15	-179		-59					88	207		23			263		-179				
Year 25	-162		-55					119	254		41			286		-162				
Year 50	-148		-51					152	295		58			303		-148				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-199			-187		-75			-181		-101		-44							
Year 5	-199			-187		5			101		-15		70							
Year 15	-179			-179		32			207		23		131							
Year 25	-162			-172		47			254		41		159							
Year 50	-148			-167		62			295		58		181							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-199		-64	-187		-75		-35	-181		-101		-44	-133		-199		-64		
Year 5	-199		-64	-187		5		41	101		-15		70	175		-199		-64		
Year 15	-179		-59	-179		32		88	207		23		131	263		-179		-59		
Year 25	-162		-55	-172		47		119	254		41		159	286		-162		-54		
Year 50	-148		-51	-167		62		152	295		58		181	303		-148		-51		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-350		-110		-350	-139		-58	-151	-159	-159		-70	-129	-159	-350		-110		-350
Year 5	-350		-110		-350	23		54	69	16	16		82	108	16	-350		-110		-350
Year 15	-326		-100		-326	77		114	145	78	78		157	178	78	-326		-100		-326
Year 25	-305		-92		-305	105		152	182	105	105		189	199	105	-305		-92		-305
Year 50	-289		-86		-289	132		192	216	127	127		216	215	127	-289		-86		-289
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-181	-181		0	0	-181	-181		0	0	-291	-291		0
Year 5	0				0	0	173	173		0	0	173	173		0	0	-291	-291		0
Year 15	0				0	0	232	232		0	0	233	233		0	0	-291	-291		0
Year 25	0				0	0	244	244		0	0	244	244		0	0	-291	-291		0
Year 50	0				0	0	253	253		0	0	253	253		0	0	-291	-291		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-40
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 47

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-68		-19	-88		5		-21	-127		-3		-38	-160		-73		-23	-97	
Year 5	-68		-19	-88		64		23	66		64		25	63		-73		-23	-96	
Year 15	-43		-7	-57		87		57	150		99		81	157		-48		-11	-67	
Year 25	-20		4	-32		103		86	193		118		110	187		-26		-1	-44	
Year 50	-2		11	-14		127		125	234		135		133	210		-9		7	-26	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-68		-19					-21	-127		-3			-160		-73				
Year 5	-68		-19					23	66		64			63		-73				
Year 15	-43		-7					57	150		99			157		-48				
Year 25	-20		4					86	193		118			187		-26				
Year 50	-2		11					125	234		135			210		-9				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-68			-88		5			-127		-3		-38							
Year 5	-68			-88		64			66		64		25							
Year 15	-43			-57		87			150		99		81							
Year 25	-20			-32		103			193		118		110							
Year 50	-2			-14		127			234		135		133							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-68		-19	-88		5		-21	-127		-3		-38	-160		-73		-23		
Year 5	-68		-19	-88		64		23	66		64		25	63		-73		-23		
Year 15	-43		-7	-57		87		57	150		99		81	157		-48		-11		
Year 25	-20		4	-32		103		86	193		118		110	187		-26		-1		
Year 50	-2		11	-14		127		125	234		135		133	210		-9		7		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-125		-35		-125	22		-36	-115	8	8		-59	-145	8	-134		-41		-134
Year 5	-125		-35		-125	142		34	38	143	143		34	31	143	-134		-41		-134
Year 15	-87		-13		-87	187		79	100	207	207		105	105	207	-96		-20		-96
Year 25	-55		5		-55	216		115	135	236	236		141	132	236	-66		-2		-66
Year 50	-30		18		-30	254		164	171	260	260		170	153	260	-41		11		-41
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-161	-161		0	0	-174	-174		0	0	-127	-127		0
Year 5	0				0	0	87	87		0	0	80	80		0	0	-127	-127		0
Year 15	0				0	0	129	129		0	0	123	123		0	0	-127	-127		0
Year 25	0				0	0	137	137		0	0	131	131		0	0	-127	-127		0
Year 50	0				0	0	143	143		0	0	137	137		0	0	-127	-127		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-41
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 47.9

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-102		-28	-81		-31		-14	-93		-48		-34	-103		-108		-30	-80	
Year 5	-102		-28	-81		13		26	58		2		26	74		-108		-29	-79	
Year 15	-88		-21	-68		28		51	118		26		67	134		-93		-22	-67	
Year 25	-74		-15	-57		36		69	145		38		86	151		-81		-17	-58	
Year 50	-63		-10	-49		44		87	170		49		102	164		-69		-12	-51	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-102		-28					-14	-93		-48			-103		-108				
Year 5	-102		-28					26	58		2			74		-108				
Year 15	-88		-21					51	118		26			134		-93				
Year 25	-74		-15					69	145		38			151		-81				
Year 50	-63		-10					87	170		49			164		-69				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-102			-81		-31			-93		-48		-34							
Year 5	-102			-81		13			58		2		26							
Year 15	-88			-68		28			118		26		67							
Year 25	-74			-57		36			145		38		86							
Year 50	-63			-49		44			170		49		102							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-102		-28	-81		-31		-14	-93		-48		-34	-103		-108		-30		
Year 5	-102		-28	-81		13		26	58		2		26	74		-108		-29		
Year 15	-88		-21	-68		28		51	118		26		67	134		-93		-22		
Year 25	-74		-15	-57		36		69	145		38		86	151		-81		-17		
Year 50	-63		-10	-49		44		87	170		49		102	164		-69		-12		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-190		-47		-190	-56		-25	-77	-79	-79		-52	-96	-79	-198		-50		-198
Year 5	-190		-47		-190	32		34	41	23	23		31	41	23	-198		-50		-198
Year 15	-170		-35		-170	62		67	84	63	63		81	88	63	-178		-38		-178
Year 25	-152		-25		-152	78		88	105	81	81		104	104	81	-161		-28		-161
Year 50	-137		-17		-137	94		111	125	97	97		123	116	97	-147		-21		-147
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-105	-105		0	0	-119	-119		0	0	-113	-113		0
Year 5	0				0	0	87	87		0	0	84	84		0	0	-113	-113		0
Year 15	0				0	0	119	119		0	0	117	117		0	0	-113	-113		0
Year 25	0				0	0	125	125		0	0	124	124		0	0	-113	-113		0
Year 50	0				0	0	130	130		0	0	129	129		0	0	-113	-113		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-42
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 48.2

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-81		-28	-99		-19		-5	-60		-31		-18	-64		-84		-30	-100	
Year 5	-81		-28	-99		23		34	87		15		37	100		-84		-29	-100	
Year 15	-67		-24	-88		38		59	146		37		76	157		-70		-25	-89	
Year 25	-55		-20	-79		46		76	173		48		95	174		-58		-21	-81	
Year 50	-44		-17	-72		54		95	197		58		111	186		-47		-19	-74	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-81		-28					-5	-60		-31			-64		-84				
Year 5	-81		-28					34	87		15			100		-84				
Year 15	-67		-24					59	146		37			157		-70				
Year 25	-55		-20					76	173		48			174		-58				
Year 50	-44		-17					95	197		58			186		-47				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-81			-99		-19			-60		-31		-18							
Year 5	-81			-99		23			87		15		37							
Year 15	-67			-88		38			146		37		76							
Year 25	-55			-79		46			173		48		95							
Year 50	-44			-72		54			197		58		111							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-81		-28	-99		-19		-5	-60		-31		-18	-64		-84		-30		
Year 5	-81		-28	-99		23		34	87		15		37	100		-84		-29		
Year 15	-67		-24	-88		38		59	146		37		76	157		-70		-25		
Year 25	-55		-20	-79		46		76	173		48		95	174		-58		-21		
Year 50	-44		-17	-72		54		95	197		58		111	186		-47		-19		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-148		-50		-148	-30		-12	-52	-46	-46		-30	-63	-46	-152		-52		-152
Year 5	-148		-50		-148	56		46	64	47	47		47	64	47	-152		-52		-152
Year 15	-128		-41		-128	85		79	106	85	85		94	109	85	-133		-44		-133
Year 25	-112		-35		-112	100		100	126	102	102		117	124	102	-116		-37		-116
Year 50	-98		-29		-98	116		122	146	116	116		136	136	116	-103		-32		-103
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-67	-67		0	0	-70	-70		0	0	-136	-136		0
Year 5	0				0	0	120	120		0	0	116	116		0	0	-136	-136		0
Year 15	0				0	0	151	151		0	0	147	147		0	0	-136	-136		0
Year 25	0				0	0	158	158		0	0	153	153		0	0	-136	-136		0
Year 50	0				0	0	162	162		0	0	158	158		0	0	-136	-136		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-43

SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 62.5

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-26		-10	-42		-10		-4	-26		-15		-13	-35		-28		-12	-44	
Year 5	-26		-10	-42		2		8	19		-1		4	15		-28		-12	-43	
Year 15	-21		-8	-37		7		16	37		6		16	33		-23		-10	-39	
Year 25	-17		-7	-33		11		23	47		10		22	38		-19		-9	-36	
Year 50	-13		-6	-30		16		33	55		13		27	42		-16		-8	-33	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-26		-10					-4	-26		-15			-35		-28				
Year 5	-26		-10					8	19		-1			15		-28				
Year 15	-21		-8					16	37		6			33		-23				
Year 25	-17		-7					23	47		10			38		-19				
Year 50	-13		-6					33	55		13			42		-16				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-26			-42		-10			-26		-15		-13							
Year 5	-26			-42		2			19		-1		4							
Year 15	-21			-37		7			37		6		16							
Year 25	-17			-33		11			47		10		22							
Year 50	-13			-30		16			55		13		27							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-26		-10	-42		-10		-4	-26		-15		-13	-35		-28		-12		
Year 5	-26		-10	-42		2		8	19		-1		4	15		-28		-12		
Year 15	-21		-8	-37		7		16	37		6		16	33		-23		-10		
Year 25	-17		-7	-33		11		23	47		10		22	38		-19		-9		
Year 50	-13		-6	-30		16		33	55		13		27	42		-16		-8		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-51		-18		-51	-20		-7	-22	-26	-26		-19	-32	-26	-54		-20		-54
Year 5	-51		-18		-51	6		11	13	3	3		5	7	3	-54		-20		-54
Year 15	-44		-15		-44	16		21	27	15	15		20	21	15	-47		-17		-47
Year 25	-38		-12		-38	22		30	34	20	20		27	26	20	-42		-15		-42
Year 50	-33		-10		-33	30		41	42	24	24		33	29	24	-37		-13		-37
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-31	-31		0	0	-40	-40		0	0	-57	-57		0
Year 5	0				0	0	26	26		0	0	17	17		0	0	-57	-57		0
Year 15	0				0	0	35	35		0	0	27	27		0	0	-57	-57		0
Year 25	0				0	0	37	37		0	0	28	28		0	0	-57	-57		0
Year 50	0				0	0	39	39		0	0	30	30		0	0	-57	-57		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-44
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 68.9

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-34		-7	-46		12		12	-6		14		14	-1		-34		-8	-47	
Year 5	-34		-7	-46		52		46	131		59		60	159		-34		-7	-47	
Year 15	-16		-1	-25		68		73	196		85		108	237		-16		-2	-26	
Year 25	-1		3	-9		79		98	230		99		135	264		-1		3	-10	
Year 50	12		7	4		97		132	264		112		157	284		12		6	2	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-34		-7					12	-6		14			-1		-34				
Year 5	-34		-7					46	131		59			159		-34				
Year 15	-16		-1					73	196		85			237		-16				
Year 25	-1		3					98	230		99			264		-1				
Year 50	12		7					132	264		112			284		12				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-34			-46		12			-6		14		14							
Year 5	-34			-46		52			131		59		60							
Year 15	-16			-25		68			196		85		108							
Year 25	-1			-9		79			230		99		135							
Year 50	12			4		97			264		112		157							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-34		-7	-46		12		12	-6		14		14	-1		-34		-8		
Year 5	-34		-7	-46		52		46	131		59		60	159		-34		-7		
Year 15	-16		-1	-25		68		73	196		85		108	237		-16		-2		
Year 25	-1		3	-9		79		98	230		99		135	264		-1		3		
Year 50	12		7	4		97		132	264		112		157	284		12		6		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-61		-15		-61	31		15	-4	35	35		18	1	35	-61		-15		-61
Year 5	-61		-15		-61	112		67	105	126	126		86	126	126	-61		-15		-61
Year 15	-33		-3		-33	144		103	152	174	174		145	186	174	-33		-4		-33
Year 25	-10		6		-10	165		133	179	196	196		177	209	196	-10		5		-10
Year 50	8		13		8	194		173	209	215	215		203	227	215	8		12		8
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-40	-40		0	0	-42	-42		0	0	-111	-111		0
Year 5	0				0	0	141	141		0	0	139	139		0	0	-111	-111		0
Year 15	0				0	0	171	171		0	0	169	169		0	0	-111	-111		0
Year 25	0				0	0	177	177		0	0	175	175		0	0	-111	-111		0
Year 50	0				0	0	182	182		0	0	180	180		0	0	-111	-111		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table I-45
SAM results showing bank-line weighted relative response (feet) at Sacramento River RM 78

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	-41		-14	-65		30		21	10		18		15	2		-45		-17	-65	
Year 5	-41		-14	-65		83		69	193		67		62	177		-45		-16	-64	
Year 15	-20		-8	-46		102		105	271		95		112	250		-26		-10	-48	
Year 25	-3		-3	-32		116		135	310		115		150	289		-9		-6	-35	
Year 50	11		1	-20		138		175	347		131		179	318		4		-2	-25	
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	-41		-14					21	10		18			2		-45				
Year 5	-41		-14					69	193		67			177		-45				
Year 15	-20		-8					105	271		95			250		-26				
Year 25	-3		-3					135	310		115			289		-9				
Year 50	11		1					175	347		131			318		4				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	-41			-65		30			10		18		15							
Year 5	-41			-65		83			193		67		62							
Year 15	-20			-46		102			271		95		112							
Year 25	-3			-32		116			310		115		150							
Year 50	11			-20		138			347		131		179							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	-41		-14	-65		30		21	10		18		15	2		-45		-17		
Year 5	-41		-14	-65		83		69	193		67		62	177		-45		-16		
Year 15	-20		-8	-46		102		105	271		95		112	250		-26		-10		
Year 25	-3		-3	-32		116		135	310		115		150	289		-9		-6		
Year 50	11		1	-20		138		175	347		131		179	318		4		-2		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	-70		-28		-70	68		28	18	51	51		17	4	51	-76		-31		-76
Year 5	-70		-28		-70	174		99	161	151	151		85	140	151	-76		-31		-76
Year 15	-41		-16		-41	214		145	218	200	200		147	198	200	-49		-20		-49
Year 25	-17		-6		-17	239		181	249	231	231		191	231	231	-26		-10		-26
Year 50	2		2		2	272		229	282	256	256		226	256	256	-8		-3		-8
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	88	88		0	0	90	90		0	0	-46	-46		0
Year 5	0				0	0	322	322		0	0	325	325		0	0	-46	-46		0
Year 15	0				0	0	361	361		0	0	364	364		0	0	-46	-46		0
Year 25	0				0	0	369	369		0	0	372	372		0	0	-46	-46		0
Year 50	0				0	0	375	375		0	0	378	378		0	0	-46	-46		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).